LArray Documentation

Release 0.31-dev

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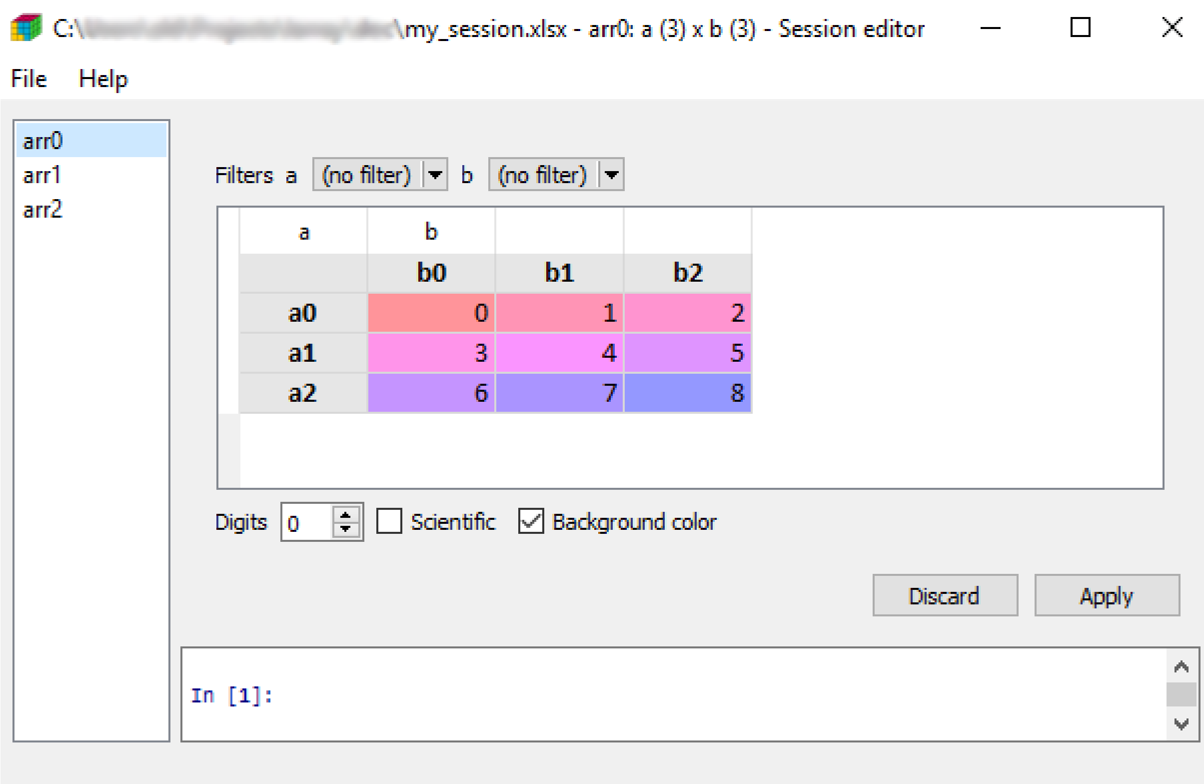
LArray is open source Python library that aims to provide tools for easy exploration and manipulation of N-dimensional labelled data structures.

CHAPTER

ONE

LIBRARY HIGHLIGHTS

- N-dimensional labelled array objects to store and manipulate multi-dimensional data
- I/O functions for reading and writing arrays in different formats: CSV, Microsoft Excel, HDF5, pickle
- Arrays can be grouped into Session objects and loaded/dumped at once
- User interface with an IPython console for rapid exploration of data
- Compatible with the pandas library: LArray objects can be converted into pandas DataFrame and vice versa.



CHAPTER

TWO

DOCUMENTATION

The official documentation is hosted on ReadTheDocs at http://larray.readthedocs.io/en/stable/

CHAPTER

THREE

GET IN TOUCH

- To be informed of each new release, please subscribe to the announce mailing list.
- For questions, ideas or general discussion, please use the Google Users Group.
- To report bugs, suggest features or view the source code, please go to our GitHub website.

CHAPTER

FOUR

CONTENTS

4.1 Installation

4.1.1 Pre-built binaries

The easiest route to installing larray is through Conda. For all platforms installing larray can be done with:

```
conda install -c gdementen larray
```

This will install a lightweight version of larray depending only on Numpy and Pandas libraries only. Additional libraries are required to use the included graphical user interface, make plots or use special I/O functions for easy dump/load from Excel or HDF files. Optional dependencies are described below.

Installing larray with all optional dependencies can be done with

```
conda install -c gdementen larrayenv
```

You can also first add the channel *gdementen* to your channel list

```
conda config --add channels gdementen
```

and then install larray (or larrayenv) as

```
conda install larray
```

4.1.2 Building from source

The latest release of LArray is available from https://github.com/larray-project/larray.git

Once you have satisfied the requirements detailed below, simply run:

```
python setup.py install
```

4.1.3 Required Dependencies

- Python 2.7, 3.5, or 3.6
- numpy (1.10.0 or later)
- pandas (0.13.1 or later)

4.1.4 Optional Dependencies

For IO (HDF, Excel)

- pytables: for working with files in HDF5 format.
- xlwings: recommended package to get benefit of all Excel features of LArray. Only available on Windows and Mac platforms.
- xlrd: for reading data and formatting information from older Excel files (ie: .xls)
- openpyxl: recommended package for reading and writing Excel 2010 files (ie: .xlsx)
- xlsxwriter: alternative package for writing data, formatting information and, in particular, charts in the Excel 2010 format (ie: .xlsx)
- larray_eurostat: provides functions to easily download EUROSTAT files as larray objects. Currently limited to TSV files.

For Graphical User Interface

LArray includes a graphical user interface to view, edit and compare arrays.

- pyqt (4 or 5): required by *larray-editor* (see below).
- pyside: alternative to PyQt.
- qtpy: required by *larray-editor*. Provides support for PyQt5, PyQt4 and PySide using the PyQt5 layout.
- larray-editor: required to use the graphical user interface associated with larray. It assumes that *qtpy* and *pyqt* or *pyside* are installed. On windows, creates also a menu `LArray` in the Windows Start Menu.

For plotting

- matplotlib: required for plotting.

4.1.5 Update

If larray has been installed using conda, update is done via

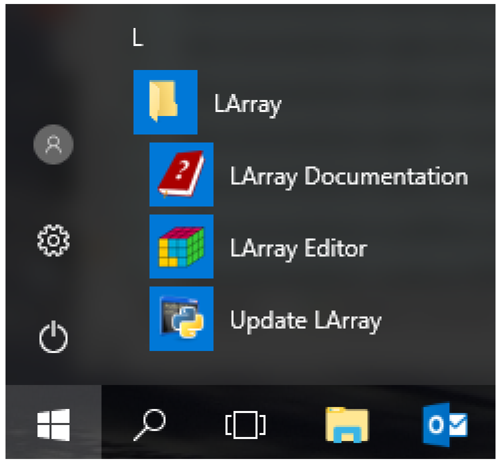
```
conda update larray
```

Be careful if you have installed optional dependencies. In that case, you may have to update some of them.

If larray has been installed using conda via larrayenv, you simply must do

```
conda update larrayenv
```

For Windows users who have larrayenv (>= 0.25) installed, simply click on the `Update LArray` link in the the Windows Start Menu > LArray.



4.2 Tutorial

This is an overview of the LArray library. It is not intended to be a fully comprehensive manual. It is mainly dedicated to help new users to familiarize with it and others to remind essentials.

4.2.1 Getting Started

The purpose of the present **Getting Started** section is to give a quick overview of the main objects and features of the LArray library. To get a more detailed presentation of all capabilities of LArray, read the next sections of the tutorial. The *API Reference* section of the documentation give you the list of all objects, methods and functions with their individual documentation and examples.

To use the LArray library, the first thing to do is to import it:

```
In [1]: from larray import *
```

Create an array

Working with the LArray library mainly consists of manipulating *LArray* data structures. They represent N-dimensional labelled arrays and are composed of raw data (NumPy ndarray), *axes* and optionally some metadata.

An axis represents a dimension of an array. It contains a list of labels and has a name:

```
# define some axes to be used later
In [2]: age = Axis(['0-9', '10-17', '18-66', '67+'], 'age')

In [3]: sex = Axis(['F', 'M'], 'sex')

In [4]: year = Axis([2015, 2016, 2017], 'year')
```

The labels allow to select subsets and to manipulate the data without working with the positions of array elements directly.

To create an array from scratch, you need to supply data and axes:

```
# define some data. This is the belgian population (in thousands). Source: eurostat.
In [5]: data = [[[633, 635, 634],
   ...:          [663, 665, 664]],
   ...:         [[484, 486, 491],
   ...:          [505, 511, 516]],
   ...:         [[3572, 3581, 3583],
   ...:          [3600, 3618, 3616]],
   ...:         [[1023, 1038, 1053],
   ...:          [756, 775, 793]]]
   ...:

# create an LArray object
In [6]: pop = LArray(data, axes=[age, sex, year])

In [7]: pop
Out[7]:
  age  sex\year  2015  2016  2017
  0-9         F   633   635   634
  0-9         M   663   665   664
10-17         F   484   486   491
10-17         M   505   511   516
18-66         F  3572  3581  3583
18-66         M  3600  3618  3616
  67+         F  1023  1038  1053
  67+         M   756   775   793
```

You can optionally attach some metadata to an array:

```
# attach some metadata to the pop array
In [8]: pop.meta.title = 'population by age, sex and year'

In [9]: pop.meta.source = 'Eurostat'

# display metadata
In [10]: pop.meta
Out[10]:
title: population by age, sex and year
source: Eurostat
```

To get a short summary of an array, type:

```
# Array summary: metadata + dimensions + description of axes
In [11]: pop.info
Out[11]:
title: population by age, sex and year
source: Eurostat
4 x 2 x 3
 age [4]: '0-9' '10-17' '18-66' '67+'
 sex [2]: 'F' 'M'
 year [3]: 2015 2016 2017
dtype: int64
memory used: 192 bytes
```

Create an array filled with predefined values

Arrays filled with predefined values can be generated through dedicated functions:

- *zeros()* : creates an array filled with 0

```
In [12]: zeros([age, sex])
Out[12]:
age\sex    F    M
    0-9  0.0  0.0
  10-17  0.0  0.0
  18-66  0.0  0.0
    67+  0.0  0.0
```

- *ones()* : creates an array filled with 1

```
In [13]: ones([age, sex])
Out[13]:
age\sex    F    M
    0-9  1.0  1.0
  10-17  1.0  1.0
  18-66  1.0  1.0
    67+  1.0  1.0
```

- *full()* : creates an array filled with a given value

```
In [14]: full([age, sex], fill_value=10.0)
Out[14]:
age\sex     F     M
    0-9  10.0  10.0
  10-17  10.0  10.0
  18-66  10.0  10.0
    67+  10.0  10.0
```

- *sequence()* : creates an array by sequentially applying modifications to the array along axis.

```
In [15]: sequence(age)
Out[15]:
age  0-9  10-17  18-66  67+
       0      1      2    3
```

- *ndtest()* : creates a test array with increasing numbers as data

```
In [16]: ndtest([age, sex])
Out[16]:
age\sex  F  M
    0-9  0  1
  10-17  2  3
  18-66  4  5
    67+  6  7
```

Save/Load an array

The LArray library offers many I/O functions to read and write arrays in various formats (CSV, Excel, HDF5). For example, to save an array in a CSV file, call the method *to_csv()*:

```
# save our pop array to a CSV file
In [17]: pop.to_csv('belgium_pop.csv')
```

The content of the CSV file is then:

```
age,sex\time,2015,2016,2017
0-9,F,633,635,634
0-9,M,663,665,664
10-17,F,484,486,491
10-17,M,505,511,516
18-66,F,3572,3581,3583
18-66,M,3600,3618,3616
67+,F,1023,1038,1053
67+,M,756,775,793
```

Note: In CSV or Excel files, the last dimension is horizontal and the names of the last two dimensions are separated by a \.

To load a saved array, call the function `read_csv()`:

```
In [18]: pop = read_csv('belgium_pop.csv')

In [19]: pop
Out[19]: 
  age  sex\year  2015  2016  2017
  0-9         F   633   635   634
  0-9         M   663   665   664
10-17         F   484   486   491
10-17         M   505   511   516
18-66         F  3572  3581  3583
18-66         M  3600  3618  3616
  67+         F  1023  1038  1053
  67+         M   756   775   793
```

Other input/output functions are described in the *Input/Output* section of the API documentation.

Selecting a subset

To select an element or a subset of an array, use brackets [ ]. In Python we usually use the term *indexing* for this operation.

Let us start by selecting a single element:

```
In [20]: pop['67+', 'F', 2017]
Out[20]: 1053
```

Labels can be given in arbitrary order:

```
In [21]: pop[2017, 'F', '67+']
Out[21]: 1053
```

When selecting a larger subset the result is an array:

```
In [22]: pop[2017]
Out[22]: 
age\sex     F     M
    0-9   634   664
  10-17   491   516
  18-66  3583  3616
    67+  1053   793
```

```
In [23]: pop['M']
Out[23]:
age\year  2015  2016  2017
     0-9   663   665   664
   10-17   505   511   516
   18-66  3600  3618  3616
     67+   756   775   793
```

When selecting several labels for the same axis, they must be given as a list (enclosed by `[ ]`)

```
In [24]: pop['F', ['0-9', '10-17']]
Out[24]:
age\year  2015  2016  2017
     0-9   633   635   634
   10-17   484   486   491
```

You can also select *slices*, which are all labels between two bounds (we usually call them the *start* and *stop* bounds). Specifying the *start* and *stop* bounds of a slice is optional: when not given, *start* is the first label of the corresponding axis, *stop* the last one:

```
# in this case '10-17':'67+' is equivalent to ['10-17', '18-66', '67+']
In [25]: pop['F', '10-17':'67+']
Out[25]:
age\year  2015  2016  2017
   10-17   484   486   491
   18-66  3572  3581  3583
     67+  1023  1038  1053

# :'18-66' selects all labels between the first one and '18-66'
# 2017: selects all labels between 2017 and the last one
In [26]: pop[:'18-66', 2017:]
Out[26]:
  age  sex\year  2017
  0-9         F   634
  0-9         M   664
10-17         F   491
10-17         M   516
18-66         F  3583
18-66         M  3616
```

Note: Contrary to slices on normal Python lists, the `stop` bound **is** included in the selection.

Warning: Selecting by labels as above only works as long as there is no ambiguity. When several axes have some labels in common and you do not specify explicitly on which axis to work, it fails with an error ending with something like ValueError: <somelabel> is ambiguous (valid in <axis1>, <axis2>).

For example, let us create a test array with an ambiguous label. We first create an axis (some kind of status code) with an 'F' label (remember we already have an 'F' label on the sex axis).

```
In [27]: status = Axis(['A', 'C', 'F'], 'status')
```

Then create a test array using both axes 'sex' and 'status':

```
In [28]: ambiguous_arr = ndtest([sex, status, year])

In [29]: ambiguous_arr
Out[29]:
sex  status\year  2015  2016  2017
  F            A     0     1     2
  F            C     3     4     5
  F            F     6     7     8
  M            A     9    10    11
  M            C    12    13    14
  M            F    15    16    17
```

If we try to get the subset of our array concerning women (represented by the 'F' label in our array), we might try something like:

```
In [30]: ambiguous_arr[2017, 'F']
```

. . . but we receive back a volley of insults

```
[some long error message ending with the line below]
[...]
ValueError: F is ambiguous (valid in sex, status)
```

In that case, we have to specify explicitly which axis the 'F' label we want to select belongs to:

```
In [31]: ambiguous_arr[2017, sex['F']]
Out[31]:
status  A  C  F
        2  5  8
```

Aggregation

The LArray library includes many *aggregations methods*: sum, mean, min, max, std, var, . . .

For example, assuming we still have an array in the `pop` variable:

```
In [32]: pop
Out[32]:
  age  sex\year  2015  2016  2017
  0-9         F   633   635   634
  0-9         M   663   665   664
10-17         F   484   486   491
10-17         M   505   511   516
18-66         F  3572  3581  3583
18-66         M  3600  3618  3616
  67+         F  1023  1038  1053
  67+         M   756   775   793
```

We can sum along the 'sex' axis using:

```
In [33]: pop.sum(sex)
Out[33]:
age\year  2015  2016  2017
     0-9  1296  1300  1298
   10-17   989   997  1007
```

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```
   18-66  7172  7199  7199
     67+  1779  1813  1846
```

Or sum along both ‘age’ and ‘sex’:

```
In [34]: pop.sum(age, sex)
Out[34]:
year   2015   2016   2017
      11236  11309  11350
```

It is sometimes more convenient to aggregate along all axes **except** some. In that case, use the aggregation methods ending with *_by*. For example:

```
In [35]: pop.sum_by(year)
Out[35]:
year   2015   2016   2017
      11236  11309  11350
```

Groups

A *Group* represents a subset of labels or positions of an axis:

```
In [36]: children = age['0-9', '10-17']

In [37]: children
Out[37]: age['0-9', '10-17']
```

It is often useful to attach them an explicit name using the >> operator:

```
In [38]: working = age['18-66'] >> 'working'

In [39]: working
Out[39]: age['18-66'] >> 'working'

In [40]: nonworking = age['0-9', '10-17', '67+'] >> 'nonworking'

In [41]: nonworking
Out[41]: age['0-9', '10-17', '67+'] >> 'nonworking'
```

Still using the same `pop` array:

```
In [42]: pop
Out[42]:
  age  sex\year  2015  2016  2017
  0-9         F   633   635   634
  0-9         M   663   665   664
10-17         F   484   486   491
10-17         M   505   511   516
18-66         F  3572  3581  3583
18-66         M  3600  3618  3616
  67+         F  1023  1038  1053
  67+         M   756   775   793
```

Groups can be used in selections:

```
In [43]: pop[working]
```

```
Out[43]:
sex\year  2015  2016  2017
       F  3572  3581  3583
       M  3600  3618  3616

In [44]: pop[nonworking]
Out[44]:
  age  sex\year  2015  2016  2017
  0-9         F   633   635   634
  0-9         M   663   665   664
10-17         F   484   486   491
10-17         M   505   511   516
  67+         F  1023  1038  1053
  67+         M   756   775   793
```

or aggregations:

```
In [45]: pop.sum(nonworking)
Out[45]:
sex\year  2015  2016  2017
       F  2140  2159  2178
       M  1924  1951  1973
```

When aggregating several groups, the names we set above using >> determines the label on the aggregated axis. Since we did not give a name for the children group, the resulting label is generated automatically :

```
In [46]: pop.sum((children, working, nonworking))
Out[46]:
       age  sex\year  2015  2016  2017
 0-9,10-17         F  1117  1121  1125
 0-9,10-17         M  1168  1176  1180
   working         F  3572  3581  3583
   working         M  3600  3618  3616
nonworking         F  2140  2159  2178
nonworking         M  1924  1951  1973
```

Grouping arrays in a Session

Arrays may be grouped in *Session* objects. A session is an ordered dict-like container of LArray objects with special I/O methods. To create a session, you need to pass a list of pairs (array_name, array):

```
In [47]: pop = zeros([age, sex, year])

In [48]: births = zeros([age, sex, year])

In [49]: deaths = zeros([age, sex, year])

# create a session containing the three arrays 'pop', 'births' and 'deaths'
In [50]: demo = Session(pop=pop, births=births, deaths=deaths)

# displays names of arrays contained in the session
In [51]: demo.names
Out[51]: ['births', 'deaths', 'pop']

# get an array
```

```
In [52]: demo['pop']
Out[52]:
  age  sex\year  2015  2016  2017
  0-9         F   0.0   0.0   0.0
  0-9         M   0.0   0.0   0.0
10-17         F   0.0   0.0   0.0
10-17         M   0.0   0.0   0.0
18-66         F   0.0   0.0   0.0
18-66         M   0.0   0.0   0.0
  67+         F   0.0   0.0   0.0
  67+         M   0.0   0.0   0.0

# add/modify an array
In [53]: demo['foreigners'] = zeros([age, sex, year])
```

> **Warning:** If you are using a Python version prior to 3.6, you will have to pass a list of pairs to the Session constructor otherwise the arrays will be stored in an arbitrary order in the new session. For example, the session above must be created using the syntax: *demo=Session([('pop', pop), ('births', births), ('deaths', deaths)]).*

One of the main interests of using sessions is to save and load many arrays at once:

```
# dump all arrays contained in the session 'demo' in one HDF5 file
In [54]: demo.save('demo.h5')

# load all arrays saved in the HDF5 file 'demo.h5' and store them in the session 'demo
↪'
In [55]: demo = Session('demo.h5')
```

Graphical User Interface (viewer)

The LArray project provides an optional package called *larray-editor* allowing users to explore and edit arrays through a graphical interface. The larray-editor tool is automatically available when installing the **larrayenv** metapackage from conda.

To explore the content of arrays in read-only mode, import `larray-editor` and call `view()`

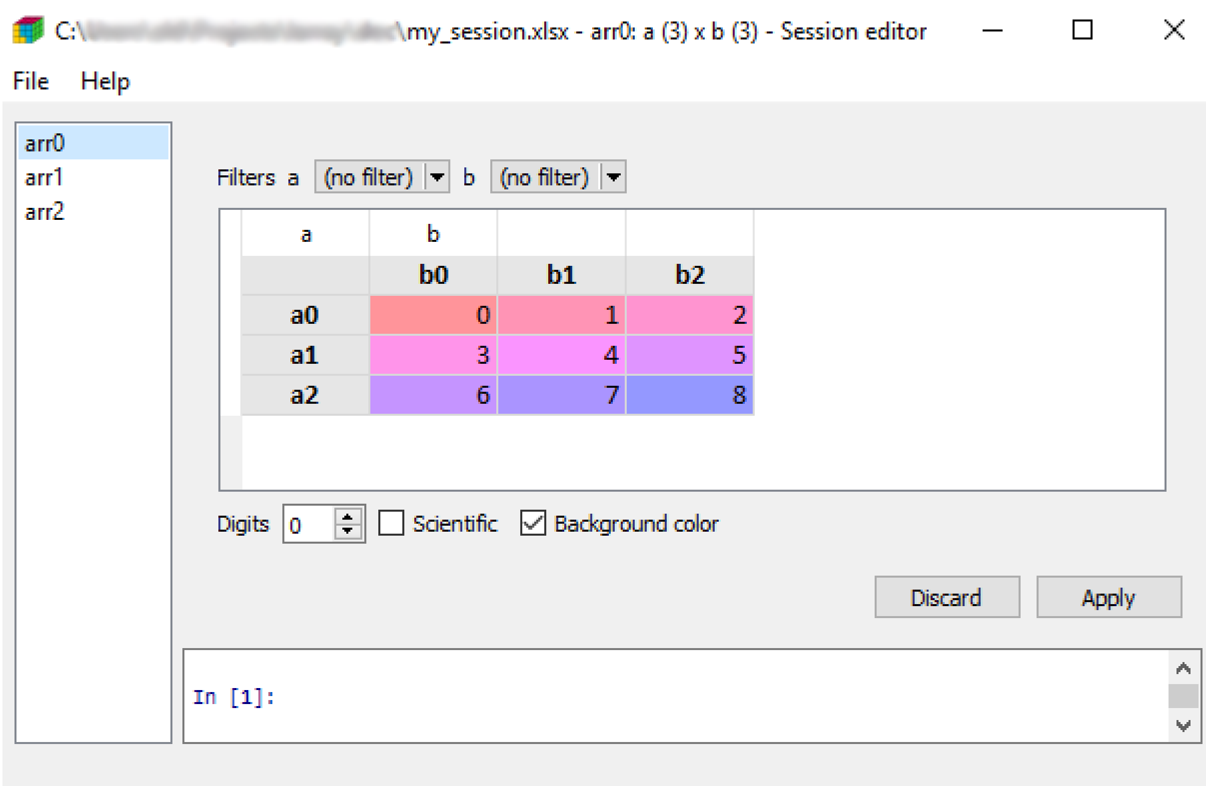
```
In [56]: from larray_editor import *

# shows the arrays of a given session in a graphical user interface
In [57]: view(ses)

# the session may be directly loaded from a file
In [58]: view('my_session.h5')

# creates a session with all existing arrays from the current namespace
# and shows its content
In [59]: view()
```

To open the user interface in edit mode, call `edit()` instead.



Once open, you can save and load any session using the *File* menu.

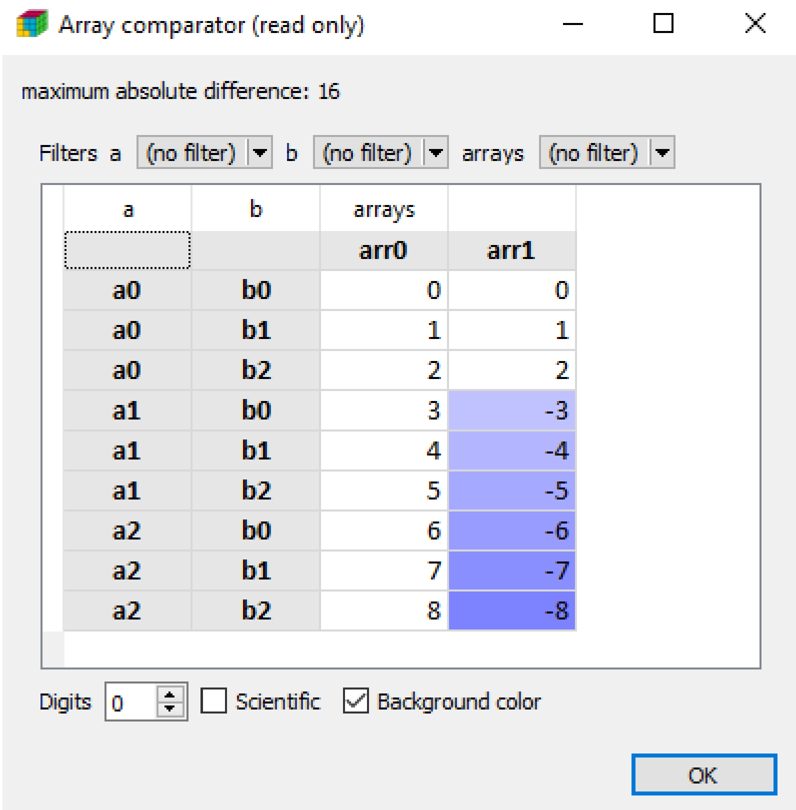
Finally, you can also visually compare two arrays or sessions using the `compare()` function.

```
In [60]: arr0 = ndtest((3, 3))

In [61]: arr1 = ndtest((3, 3))

In [62]: arr1[['a1', 'a2']] = -arr1[['a1', 'a2']]

In [63]: compare(arr0, arr1)
```

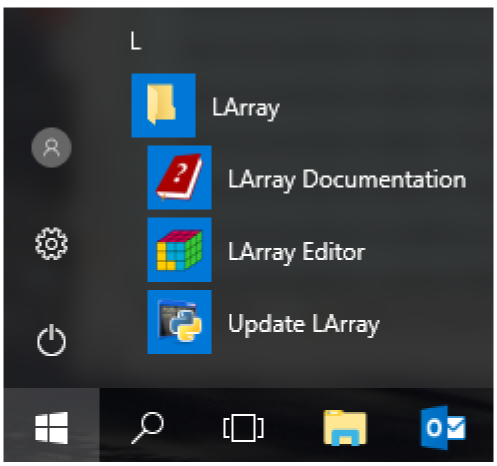


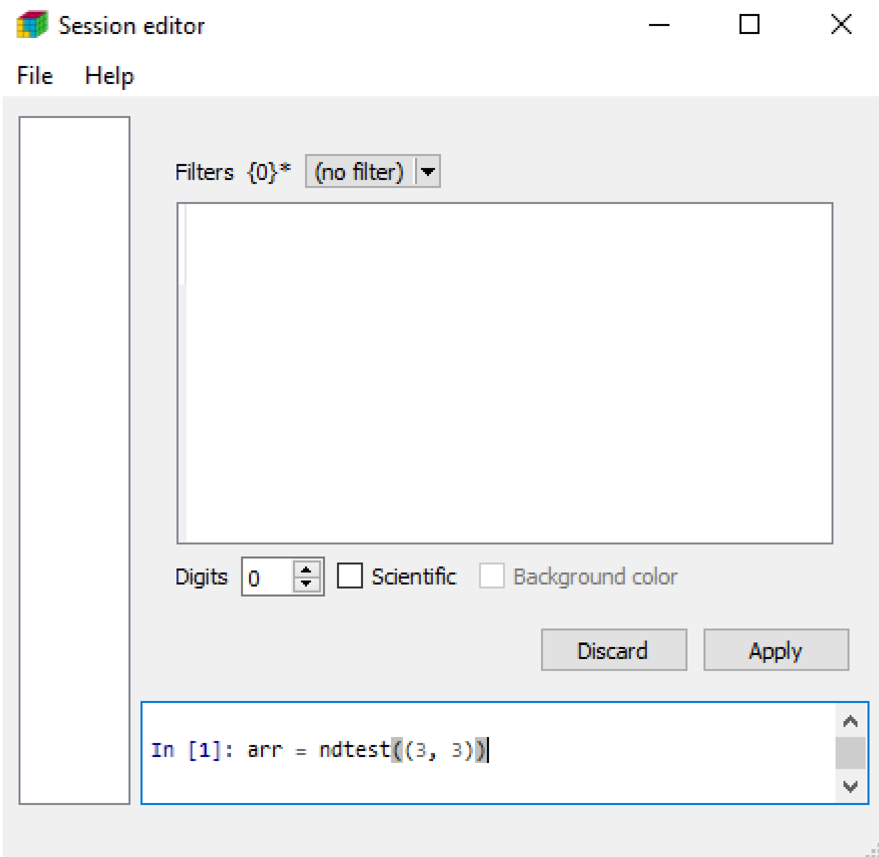
In case of two arrays, they must have compatible axes.

For Windows Users

Installing the `larray-editor` package on Windows will create a `LArray` menu in the Windows Start Menu. This menu contains:

- a shortcut to open the documentation of the last stable version of the library
- a shortcut to open the graphical interface in edit mode.
- a shortcut to update *larrayenv*.





Once the graphical interface is open, all LArray objects and functions are directly accessible. No need to start by *from larray import **.

4.2.2 Presenting LArray objects (Axis, Groups, LArray, Session)

Import the LArray library:

```
[2]: from larray import *
```

Check the version of LArray:

```
[3]: from larray import __version__
     __version__
```

```
[3]: '0.31-dev'
```

Axis

An `Axis` represents a dimension of an LArray object. It consists of a name and a list of labels.

They are several ways to create an axis:

```
[4]: # create a wildcard axis
     age = Axis(3, 'age')
     # labels given as a list
     time = Axis([2007, 2008, 2009], 'time')
```

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```
# create an axis using one string
sex = Axis('sex=M,F')
# labels generated using a special syntax
other = Axis('other=A01..C03')

age, sex, time, other
```

```
[4]: (Axis(3, 'age'),
 Axis(['M', 'F'], 'sex'),
 Axis([2007, 2008, 2009], 'time'),
 Axis(['A01', 'A02', 'A03', 'B01', 'B02', 'B03', 'C01', 'C02', 'C03'], 'other'))
```

See the *Axis* section of the API Reference to explore all methods of Axis objects.

Groups

A `Group` represents a selection of labels from an Axis. It can optionally have a name (using operator >>). Groups can be used when selecting a subset of an array and in aggregations.

Group objects are created as follow:

```
[5]: # define an Axis object 'age'
age = Axis('age=0..100')

# create an anonymous Group object 'teens'
teens = age[10:20]
# create a Group object 'pensioners' with a name
pensioners = age[67:] >> 'pensioners'

teens
```

```
[5]: age[10:20]
```

It is possible to set a name or to rename a group after its declaration:

```
[6]: # method 'named' returns a new group with the given name
teens = teens.named('teens')

# operator >> is just a shortcut for the call of the method named
teens = teens >> 'teens'

teens
```

```
[6]: age[10:20] >> 'teens'
```

See the *Group* section of the API Reference to explore all methods of Group objects.

LArray

A `LArray` object represents a multidimensional array with labeled axes.

Create an array from scratch

To create an array from scratch, you need to provide the data and a list of axes. Optionally, metadata (title, description, creation date, authors, . . .) can be associated to the array:

[7]:
```
import numpy as np

# list of the axes
axes = [age, sex, time, other]
# data (the shape of data array must match axes lengths)
data = np.random.randint(100, size=[len(axis) for axis in axes])
# metadata
meta = [('title', 'random array')]

arr = LArray(data, axes, meta=meta)
arr
```

[7]:
```
age  sex  time\other  A01  A02  A03  B01  B02  B03  C01  C02  C03
  0    M        2007   70    3    5   45   91   52   96   28   90
  0    M        2008   17   69   16    6   38   17   29   87    9
  0    M        2009   66   17   43   67    0   33   52   20   72
  0    F        2007   47   49    8   63    4   86   33   23    6
  0    F        2008   77    1   64   19   93   90   74   87   93
...  ...         ...  ...  ...  ...  ...  ...  ...  ...  ...  ...
100    M        2008   11   89   14   40   73   32   53   45   98
100    M        2009   45   89   60   26   40   12   78   19   94
100    F        2007   88   52   15   22   56   42   29   13   23
100    F        2008   61   25   97   86    9   20   59   66   40
100    F        2009   61   27   21   53   66   24   36   38   71
```

Metadata can be added to an array at any time using:

[8]:
```
arr.meta.description = 'array containing random values between 0 and 100'

arr.meta
```

[8]:
```
title: random array
description: array containing random values between 0 and 100
```

Warning:

Currently, only the HDF (.h5) file format supports saving and loading array metadata.

Metadata is not kept when actions or methods are applied on an array except for operations modifying the object in-place, such as `pop[age < 10] = 0`, and when the method `copy()` is called. Do not add metadata to an array if you know you will apply actions or methods on it before dumping it.

Array creation functions

Arrays can also be generated in an easier way through *creation functions*:

- `ndtest` : creates a test array with increasing numbers as data
- `empty` : creates an array but leaves its allocated memory unchanged (i.e., it contains "garbage". Be careful !)
- `zeros`: fills an array with 0
- `ones` : fills an array with 1
- `full` : fills an array with a given value
- `sequence` : creates an array from an axis by iteratively applying a function to a given initial value.

Except for ndtest, a list of axes must be provided. Axes can be passed in different ways:

- as Axis objects
- as integers defining the lengths of auto-generated wildcard axes
- as a string : 'sex=M,F;time=2007,2008,2009' (name is optional)
- as pairs (name, labels)

Optionally, the type of data stored by the array can be specified using argument dtype.

[9]:
```
# start defines the starting value of data
ndtest(['age=0..2', 'sex=M,F', 'time=2007..2009'], start=-1)
```

[9]:
```
age  sex\time  2007  2008  2009
  0         M    -1     0     1
  0         F     2     3     4
  1         M     5     6     7
  1         F     8     9    10
  2         M    11    12    13
  2         F    14    15    16
```

[10]:
```
# start defines the starting value of data
# label_start defines the starting index of labels
ndtest((3, 3), start=-1, label_start=2)
```

[10]:
```
a\b  b2  b3  b4
 a2  -1   0   1
 a3   2   3   4
 a4   5   6   7
```

[11]:
```
# empty generates uninitialised array with correct axes
# (much faster but use with care!).
# This not really random either, it just reuses a portion
# of memory that is available, with whatever content is there.
# Use it only if performance matters and make sure all data
# will be overridden.
empty(['age=0..2', 'sex=M,F', 'time=2007..2009'])
```

[11]:
```
age  sex\time  ...
  0         M  ...
  0         F  ...
  1         M  ...
  1         F  ...
  2         M  ...
  2         F  ...
```

[12]:
```
# example with anonymous axes
zeros(['0..2', 'M,F', '2007..2009'])
```

[12]:
```
{0}  {1}\{2}  2007  2008  2009
  0        M   0.0   0.0   0.0
  0        F   0.0   0.0   0.0
  1        M   0.0   0.0   0.0
  1        F   0.0   0.0   0.0
  2        M   0.0   0.0   0.0
  2        F   0.0   0.0   0.0
```

[13]:
```
# dtype=int forces to store int data instead of default float
ones(['age=0..2', 'sex=M,F', 'time=2007..2009'], dtype=int)
```

[13]:
```
age  sex\time  2007  2008  2009
  0         M     1     1     1
  0         F     1     1     1
  1         M     1     1     1
  1         F     1     1     1
  2         M     1     1     1
  2         F     1     1     1
```

[14]:
```
full(['age=0..2', 'sex=M,F', 'time=2007..2009'], 1.23)
```

[14]:
```
age  sex\time  2007  2008  2009
  0         M  1.23  1.23  1.23
  0         F  1.23  1.23  1.23
  1         M  1.23  1.23  1.23
  1         F  1.23  1.23  1.23
  2         M  1.23  1.23  1.23
  2         F  1.23  1.23  1.23
```

All the above functions exist in *(func)_like* variants which take axes from another array

[15]:
```
ones_like(arr)
```

[15]:
```
age  sex  time\other  A01  A02  A03  B01  B02  B03  C01  C02  C03
  0    M        2007    1    1    1    1    1    1    1    1    1
  0    M        2008    1    1    1    1    1    1    1    1    1
  0    M        2009    1    1    1    1    1    1    1    1    1
  0    F        2007    1    1    1    1    1    1    1    1    1
  0    F        2008    1    1    1    1    1    1    1    1    1
...  ...         ...  ...  ...  ...  ...  ...  ...  ...  ...  ...
100    M        2008    1    1    1    1    1    1    1    1    1
100    M        2009    1    1    1    1    1    1    1    1    1
100    F        2007    1    1    1    1    1    1    1    1    1
100    F        2008    1    1    1    1    1    1    1    1    1
100    F        2009    1    1    1    1    1    1    1    1    1
```

Create an array using the special `sequence` function (see link to documention of `sequence` in API reference for more examples):

[16]:
```
# With initial=1.0 and inc=0.5, we generate the sequence 1.0, 1.5, 2.0, 2.5, 3.0, ...
sequence('sex=M,F', initial=1.0, inc=0.5)
```

[16]:
```
sex    M    F
     1.0  1.5
```

Inspecting LArray objects

[17]:
```
# create a test array
arr = ndtest([age, sex, time, other])
```

Get array summary : metadata + dimensions + description of axes + dtype + size in memory

[18]:
```
arr.info
```

[18]:
```
101 x 2 x 3 x 9
 age [101]: 0 1 2 ... 98 99 100
 sex [2]: 'M' 'F'
 time [3]: 2007 2008 2009
 other [9]: 'A01' 'A02' 'A03' ... 'C01' 'C02' 'C03'
dtype: int64
memory used: 42.61 Kb
```

Get axes

[19]:
```
arr.axes
```

[19]:
```
AxisCollection([
    Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20,␣
↪21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41,␣
↪42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62,␣
↪63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83,␣
↪84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100], 'age'),
    Axis(['M', 'F'], 'sex'),
    Axis([2007, 2008, 2009], 'time'),
    Axis(['A01', 'A02', 'A03', 'B01', 'B02', 'B03', 'C01', 'C02', 'C03'], 'other')
])
```

Get number of dimensions

[20]:
```
arr.ndim
```

[20]:
```
4
```

Get length of each dimension

[21]:
```
arr.shape
```

[21]:
```
(101, 2, 3, 9)
```

Get total number of elements of the array

[22]:
```
arr.size
```

[22]:
```
5454
```

Get type of internal data (int, float, . . .)

[23]:
```
arr.dtype
```

[23]:
```
dtype('int64')
```

Get size in memory

[24]:
```
arr.memory_used
```

[24]:
```
'42.61 Kb'
```

Display the array in the viewer (graphical user interface) in read-only mode. This will open a new window and block execution of the rest of code until the windows is closed! Required PyQt installed.

```
view(arr)
```

Or load it in Excel:

```
arr.to_excel()
```

More on LArray objects

To know how to save and load arrays in CSV, Excel or HDF format, please refer to the *Loading and Dumping Arrays* section of the tutorial.

See the *LArray* section of the API Reference to explore all methods of LArray objects.

Session

A `Session` object is a dictionary-like object used to gather several arrays, axes and groups. A session is particularly adapted to gather all input objects of a model or to gather the output arrays from different scenarios. Like with arrays, it is possible to associate metadata to sessions.

Creating Sessions

To create a session, you can first create an empty session and then populate it with arrays, axes and groups:

[25]:
```
# create an empty session
s_pop = Session()

# add axes to the session
gender = Axis("gender=Male,Female")
s_pop.gender = gender
time = Axis("time=2013,2014,2015")
s_pop.time = time

# add arrays to the session
s_pop.pop = zeros((gender, time))
s_pop.births = zeros((gender, time))
s_pop.deaths = zeros((gender, time))

# add metadata after creation
s_pop.meta.title = 'Demographic Model of Belgium'
s_pop.meta.description = 'Models the demography of Belgium'

# print content of the session
print(s_pop.summary())
```

```
Metadata:
        title: Demographic Model of Belgium
        description: Models the demography of Belgium
gender: gender ['Male' 'Female'] (2)
time: time [2013 2014 2015] (3)
pop: gender, time (2 x 3) [float64]
births: gender, time (2 x 3) [float64]
deaths: gender, time (2 x 3) [float64]
```

or you can create and populate a session in one step:

[26]:
```
gender = Axis("gender=Male,Female")
time = Axis("time=2013,2014,2015")
```

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```
# create and populate a new session in one step
# Python <= 3.5
s_pop = Session([('gender', gender), ('time', time), ('pop', zeros((gender, time))),
                 ('births', zeros((gender, time))), ('deaths', zeros((gender, time)))],
                meta=[('title', 'Demographic Model of Belgium'),('description',
↪'Modelize the demography of Belgium')])
# Python 3.6+
s_pop = Session(gender=gender, time=time, pop=zeros((gender, time)),
                births=zeros((gender, time)), deaths=zeros((gender, time)),
                meta=Metadata(title='Demographic Model of Belgium', description=
↪'Modelize the demography of Belgium'))

# print content of the session
print(s_pop.summary())
```

```
Metadata:
        title: Demographic Model of Belgium
        description: Modelize the demography of Belgium
gender: gender ['Male' 'Female'] (2)
time: time [2013 2014 2015] (3)
pop: gender, time (2 x 3) [float64]
births: gender, time (2 x 3) [float64]
deaths: gender, time (2 x 3) [float64]
```

Warning:

Contrary to array metadata, saving and loading session metadata is supported for all current session file formats: Excel, CSV and HDF (.h5).

Metadata is not kept when actions or methods are applied on a session except for operations modifying a session in-place, such as: `s.arr1 = 0`. Do not add metadata to a session if you know you will apply actions or methods on it before dumping it.

More on Session objects

To know how to save and load sessions in CSV, Excel or HDF format, please refer to the *Loading and Dumping Sessions* section of the tutorial.

To see how to work with sessions, please read the *Working With Sessions* section of the tutorial.

Finally, see the *Session* section of the API Reference to explore all methods of Session objects.

4.2.3 Load And Dump Arrays, Sessions, Axes And Groups

LArray provides methods and functions to load and dump LArray, Session, Axis Group objects to several formats such as Excel, CSV and HDF5. The HDF5 file format is designed to store and organize large amounts of data. It allows to read and write data much faster than when working with CSV and Excel files.

```
[2]: # first of all, import the LArray library
from larray import *
```

Check the version of LArray:

```
[3]: from larray import __version__
     __version__
```

```
[3]: '0.31-dev'
```

Loading and Dumping Arrays

Loading Arrays - Basic Usage (CSV, Excel, HDF5)

To read an array from a CSV file, you must use the `read_csv` function:

```
[4]: csv_dir = get_example_filepath('examples')

     # read the array pop from the file 'pop.csv'.
     # The data of the array below is derived from a subset of the demo_pjan table from␣
     ↪Eurostat
     pop = read_csv(csv_dir + '/pop.csv')
     pop
```

```
[4]: country  gender\time      2013      2014      2015
     Belgium         Male   5472856   5493792   5524068
     Belgium       Female   5665118   5687048   5713206
      France         Male  31772665  31936596  32175328
      France       Female  33827685  34005671  34280951
     Germany         Male  39380976  39556923  39835457
     Germany       Female  41142770  41210540  41362080
```

To read an array from a sheet of an Excel file, you can use the `read_excel` function:

```
[5]: filepath_excel = get_example_filepath('examples.xlsx')

     # read the array from the sheet 'births' of the Excel file 'examples.xlsx'
     # The data of the array below is derived from a subset of the demo_fasec table from␣
     ↪Eurostat
     births = read_excel(filepath_excel, 'births')
     births
```

```
[5]: country  gender\time    2013    2014    2015
     Belgium         Male   64371   64173   62561
     Belgium       Female   61235   60841   59713
      France         Male  415762  418721  409145
      France       Female  396581  400607  390526
     Germany         Male  349820  366835  378478
     Germany       Female  332249  348092  359097
```

The `open_excel` function in combination with the `load` method allows you to load several arrays from the same Workbook without opening and closing it several times:

```
# open the Excel file 'population.xlsx' and let it opened as long as you keep the␣
↪indent.
# The Python keyword ``with`` ensures that the Excel file is properly closed even if␣
↪an error occurs
with open_excel(filepath_excel) as wb:
    # load the array 'pop' from the sheet 'pop'
    pop = wb['pop'].load()
    # load the array 'births' from the sheet 'births'
```

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```
    births = wb['births'].load()
    # load the array 'deaths' from the sheet 'deaths'
    deaths = wb['deaths'].load()

# the Workbook is automatically closed when getting out the block defined by the with␣
↪statement
```

Warning: `open_excel` requires to work on Windows and to have the library `xlwings` installed.

The `HDF5` file format is specifically designed to store and organize large amounts of data. Reading and writing data in this file format is much faster than with CSV or Excel. An HDF5 file can contain multiple arrays, each array being associated with a key. To read an array from an HDF5 file, you must use the `read_hdf` function and provide the key associated with the array:

[6]:
```
filepath_hdf = get_example_filepath('examples.h5')

# read the array from the file 'examples.h5' associated with the key 'deaths'
# The data of the array below is derived from a subset of the demo_magec table from␣
↪Eurostat
deaths = read_hdf(filepath_hdf, 'deaths')
deaths
```

[6]:
```
country  gender\time    2013    2014    2015
Belgium         Male   53908   51579   53631
Belgium       Female   55426   53176   56910
 France         Male  287410  282381  297028
 France       Female  281955  277054  296779
Germany         Male  429645  422225  449512
Germany       Female  464180  446131  475688
```

Dumping Arrays - Basic Usage (CSV, Excel, HDF5)

To write an array in a CSV file, you must use the `to_csv` method:

[7]:
```
# save the array pop in the file 'pop.csv'
pop.to_csv('pop.csv')
```

To write an array to a sheet of an Excel file, you can use the `to_excel` method:

[8]:
```
# save the array pop in the sheet 'pop' of the Excel file 'population.xlsx'
pop.to_excel('population.xlsx', 'pop')
```

Note that `to_excel` create a new Excel file if it does not exist yet. If the file already exists, a new sheet is added after the existing ones if that sheet does not already exists:

[9]:
```
# add a new sheet 'births' to the file 'population.xlsx' and save the array births in␣
↪it
births.to_excel('population.xlsx', 'births')
```

To reset an Excel file, you simply need to set the `overwrite_file` argument as True:

```
[10]: # 1. reset the file 'population.xlsx' (all sheets are removed)
      # 2. create a sheet 'pop' and save the array pop in it
      pop.to_excel('population.xlsx', 'pop', overwrite_file=True)
```

The open_excel function in combination with the dump() method allows you to open a Workbook and to export several arrays at once. If the Excel file doesn't exist, the overwrite_file argument must be set to True.

> **Warning:** The save method must be called at the end of the block defined by the *with* statement to actually write data in the Excel file, otherwise you will end up with an empty file.

```
# to create a new Excel file, argument overwrite_file must be set to True
with open_excel('population.xlsx', overwrite_file=True) as wb:
    # add a new sheet 'pop' and dump the array pop in it
    wb['pop'] = pop.dump()
    # add a new sheet 'births' and dump the array births in it
    wb['births'] = births.dump()
    # add a new sheet 'deaths' and dump the array deaths in it
    wb['deaths'] = deaths.dump()
    # actually write data in the Workbook
    wb.save()

# the Workbook is automatically closed when getting out the block defined by the with␣
↪statement
```

To write an array in an HDF5 file, you must use the to_hdf function and provide the key that will be associated with the array:

```
[11]: # save the array pop in the file 'population.h5' and associate it with the key 'pop'
      pop.to_hdf('population.h5', 'pop')
```

Specifying Wide VS Narrow format (CSV, Excel)

By default, all reading functions assume that arrays are stored in the wide format, meaning that their last axis is represented horizontally:

country \ time	2013	2014	2015
Belgium	11137974	11180840	11237274
France	65600350	65942267	66456279

By setting the wide argument to False, reading functions will assume instead that arrays are stored in the narrow format, i.e. one column per axis plus one value column:

country	time	value
Belgium	2013	11137974
Belgium	2014	11180840
Belgium	2015	11237274
France	2013	65600350
France	2014	65942267
France	2015	66456279

```
[12]: # set 'wide' argument to False to indicate that the array is stored in the 'narrow'␣
      ↪format
      pop_BE_FR = read_csv(csv_dir + '/pop_narrow_format.csv', wide=False)
      pop_BE_FR
```

```
[12]: country\time      2013      2014      2015
           Belgium  11137974  11180840  11237274
            France  65600350  65942267  66456279
```

```
[13]: # same for the read_excel function
      pop_BE_FR = read_excel(filepath_excel, sheet='pop_narrow_format', wide=False)
      pop_BE_FR
```

```
[13]: country\time      2013      2014      2015
           Belgium  11137974  11180840  11237274
            France  65600350  65942267  66456279
```

By default, writing functions will set the name of the column containing the data to 'value'. You can choose the name of this column by using the `value_name` argument. For example, using `value_name='population'` you can export the previous array as:

country	time	population
Belgium	2013	11137974
Belgium	2014	11180840
Belgium	2015	11237274
France	2013	65600350
France	2014	65942267
France	2015	66456279

```
[14]: # dump the array pop_BE_FR in a narrow format (one column per axis plus one value␣
      ↪column).
      # By default, the name of the column containing data is set to 'value'
      pop_BE_FR.to_csv('pop_narrow_format.csv', wide=False)

      # same but replace 'value' by 'population'
      pop_BE_FR.to_csv('pop_narrow_format.csv', wide=False, value_name='population')
```

```
[15]: # same for the to_excel method
      pop_BE_FR.to_excel('population.xlsx', 'pop_narrow_format', wide=False, value_name=
      ↪'population')
```

Like with the `to_excel` method, it is possible to export arrays in a `narrow` format using `open_excel`. To do so, you must set the `wide` argument of the `dump` method to False:

```
with open_excel('population.xlsx') as wb:
    # dump the array pop_BE_FR in a narrow format:
    # one column per axis plus one value column.
    # Argument value_name can be used to change the name of the
    # column containing the data (default name is 'value')
    wb['pop_narrow_format'] = pop_BE_FR.dump(wide=False, value_name='population')
    # don't forget to call save()
    wb.save()

# in the sheet 'pop_narrow_format', data is written as:
# | country | time | value    |
```

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```
# | ------- | ---- | -------- |
# | Belgium | 2013 | 11137974 |
# | Belgium | 2014 | 11180840 |
# | Belgium | 2015 | 11237274 |
# | France  | 2013 | 65600350 |
# | France  | 2014 | 65942267 |
# | France  | 2015 | 66456279 |
```

Specifying Position in Sheet (Excel)

If you want to read an array from an Excel sheet which does not start at cell `A1` (when there is more than one array stored in the same sheet for example), you will need to use the `range` argument.

Warning: Note that the `range` argument is only available if you have the library `xlwings` installed (Windows).

```
# the 'range' argument must be used to load data not starting at cell A1.
# This is useful when there is several arrays stored in the same sheet
births = read_excel(filepath_excel, sheet='pop_births_deaths', range='A9:E15')
```

Using `open_excel`, ranges are passed in brackets:

```
with open_excel(filepath_excel) as wb:
    # store sheet 'pop_births_deaths' in a temporary variable sh
    sh = wb['pop_births_deaths']
    # load the array pop from range A1:E7
    pop = sh['A1:E7'].load()
    # load the array births from range A9:E15
    births = sh['A9:E15'].load()
    # load the array deaths from range A17:E23
    deaths = sh['A17:E23'].load()

# the Workbook is automatically closed when getting out the block defined by the with␣
↪statement
```

When exporting arrays to Excel files, data is written starting at cell `A1` by default. Using the `position` argument of the `to_excel` method, it is possible to specify the top left cell of the dumped data. This can be useful when you want to export several arrays in the same sheet for example

Warning: Note that the `position` argument is only available if you have the library `xlwings` installed (Windows).

```
filename = 'population.xlsx'
sheetname = 'pop_births_deaths'

# save the arrays pop, births and deaths in the same sheet 'pop_births_and_deaths'.
# The 'position' argument is used to shift the location of the second and third␣
↪arrays to be dumped
pop.to_excel(filename, sheetname)
births.to_excel(filename, sheetname, position='A9')
deaths.to_excel(filename, sheetname, position='A17')
```

Using `open_excel`, the position is passed in brackets (this allows you to also add extra informations):

```
with open_excel('population.xlsx') as wb:
    # add a new sheet 'pop_births_deaths' and write 'population' in the first cell
    # note: you can use wb['new_sheet_name'] = '' to create an empty sheet
    wb['pop_births_deaths'] = 'population'
    # store sheet 'pop_births_deaths' in a temporary variable sh
    sh = wb['pop_births_deaths']
    # dump the array pop in sheet 'pop_births_deaths' starting at cell A2
    sh['A2'] = pop.dump()
    # add 'births' in cell A10
    sh['A10'] = 'births'
    # dump the array births in sheet 'pop_births_deaths' starting at cell A11
    sh['A11'] = births.dump()
    # add 'deaths' in cell A19
    sh['A19'] = 'deaths'
    # dump the array deaths in sheet 'pop_births_deaths' starting at cell A20
    sh['A20'] = deaths.dump()
    # don't forget to call save()
    wb.save()

# the Workbook is automatically closed when getting out the block defined by the with␣
↪statement
```

Exporting data without headers (Excel)

For some reasons, you may want to export only the data of an array without axes. For example, you may want to insert a new column containing extra information. As an exercise, let us consider we want to add the capital city for each country present in the array containing the total population by country:

country	capital city	2013	2014	2015
Belgium	Brussels	11137974	11180840	11237274
France	Paris	65600350	65942267	66456279
Germany	Berlin	80523746	80767463	81197537

Assuming you have prepared an excel sheet as below:

country	capital city	2013	2014	2015
Belgium	Brussels			
France	Paris			
Germany	Berlin			

you can then dump the data at right place by setting the `header` argument of `to_excel` to False and specifying the position of the data in sheet:

```
pop_by_country = pop.sum('gender')

# export only the data of the array pop_by_country starting at cell C2
pop_by_country.to_excel('population.xlsx', 'pop_by_country', header=False, position=
↪'C2')
```

Using `open_excel`, you can easily prepare the sheet and then export only data at the right place by either setting the `header` argument of the `dump` method to False or avoiding to call `dump`:

```
with open_excel('population.xlsx') as wb:
    # create new empty sheet 'pop_by_country'
    wb['pop_by_country'] = ''
    # store sheet 'pop_by_country' in a temporary variable sh
    sh = wb['pop_by_country']
    # write extra information (description)
    sh['A1'] = 'Population at 1st January by country'
    # export column names
    sh['A2'] = ['country', 'capital city']
    sh['C2'] = pop_by_country.time.labels
    # export countries as first column
    sh['A3'].options(transpose=True).value = pop_by_country.country.labels
    # export capital cities as second column
    sh['B3'].options(transpose=True).value = ['Brussels', 'Paris', 'Berlin']
    # export only data of pop_by_country
    sh['C3'] = pop_by_country.dump(header=False)
    # or equivalently
    sh['C3'] = pop_by_country
    # don't forget to call save()
    wb.save()

# the Workbook is automatically closed when getting out the block defined by the with␣
↪statement
```

Specifying the Number of Axes at Reading (CSV, Excel)

By default, read_csv and read_excel will search the position of the first cell containing the special character \ in the header line in order to determine the number of axes of the array to read. The special character \ is used to separate the name of the two last axes. If there is no special character \, read_csv and read_excel will consider that the array to read has only one dimension. For an array stored as:

country	gender \ time	2013	2014	2015
Belgium	Male	5472856	5493792	5524068
Belgium	Female	5665118	5687048	5713206
France	Male	31772665	31936596	32175328
France	Female	33827685	34005671	34280951
Germany	Male	39380976	39556923	39835457
Germany	Female	41142770	41210540	41362080

read_csv and read_excel will find the special character \ in the second cell meaning it expects three axes (country, gender and time).

Sometimes, you need to read an array for which the name of the last axis is implicit:

country	gender	2013	2014	2015
Belgium	Male	5472856	5493792	5524068
Belgium	Female	5665118	5687048	5713206
France	Male	31772665	31936596	32175328
France	Female	33827685	34005671	34280951
Germany	Male	39380976	39556923	39835457
Germany	Female	41142770	41210540	41362080

For such case, you will have to inform read_csv and read_excel of the number of axes of the output array by setting the `nb_axes` argument:

[16]:
```
# read the 3 x 2 x 3 array stored in the file 'pop_missing_axis_name.csv' wihout␣
↪using 'nb_axes' argument.
pop = read_csv(csv_dir + '/pop_missing_axis_name.csv')
# shape and data type of the output array are not what we expected
pop.info
```

[16]:
```
6 x 4
 country [6]: 'Belgium' 'Belgium' 'France' 'France' 'Germany' 'Germany'
 {1} [4]: 'gender' '2013' '2014' '2015'
dtype: object
memory used: 192 bytes
```

[17]:
```
# by setting the 'nb_axes' argument, you can indicate to read_csv the number of axes␣
↪of the output array
pop = read_csv(csv_dir + '/pop_missing_axis_name.csv', nb_axes=3)

# give a name to the last axis
pop = pop.rename(-1, 'time')

# shape and data type of the output array are what we expected
pop.info
```

[17]:
```
3 x 2 x 3
 country [3]: 'Belgium' 'France' 'Germany'
 gender [2]: 'Male' 'Female'
 time [3]: 2013 2014 2015
dtype: int64
memory used: 144 bytes
```

[18]:
```
# same for the read_excel function
pop = read_excel(filepath_excel, sheet='pop_missing_axis_name', nb_axes=3)
pop = pop.rename(-1, 'time')
pop.info
```

[18]:
```
3 x 2 x 3
 country [3]: 'Belgium' 'France' 'Germany'
 gender [2]: 'Male' 'Female'
 time [3]: 2013 2014 2015
dtype: int64
memory used: 144 bytes
```

NaNs and Missing Data Handling at Reading (CSV, Excel)

Sometimes, there is no data available for some label combinations. In the example below, the rows corresponding to `France - Male` and `Germany - Female` are missing:

country	gender \ time	2013	2014	2015
Belgium	Male	5472856	5493792	5524068
Belgium	Female	5665118	5687048	5713206
France	Female	33827685	34005671	34280951
Germany	Male	39380976	39556923	39835457

By default, `read_csv` and `read_excel` will fill cells associated with missing label combinations with nans. Be aware that, in that case, an int array will be converted to a float array.

[19]:
```
# by default, cells associated will missing label combinations are filled with nans.
# In that case, the output array is converted to a float array
read_csv(csv_dir + '/pop_missing_values.csv')
```

[19]:
```
country  gender\time        2013        2014        2015
Belgium         Male   5472856.0   5493792.0   5524068.0
Belgium       Female   5665118.0   5687048.0   5713206.0
 France         Male         nan         nan         nan
 France       Female  33827685.0  34005671.0  34280951.0
Germany         Male  39380976.0  39556923.0  39835457.0
Germany       Female         nan         nan         nan
```

However, it is possible to choose which value to use to fill missing cells using the `fill_value` argument:

[20]:
```
read_csv(csv_dir + '/pop_missing_values.csv', fill_value=0)
```

[20]:
```
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male         0         0         0
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female         0         0         0
```

[21]:
```
# same for the read_excel function
read_excel(filepath_excel, sheet='pop_missing_values', fill_value=0)
```

[21]:
```
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male         0         0         0
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female         0         0         0
```

Sorting Axes at Reading (CSV, Excel, HDF5)

The `sort_rows` and `sort_columns` arguments of the reading functions allows you to sort rows and columns alphabetically:

[22]:
```
# sort labels at reading --> Male and Female labels are inverted
read_csv(csv_dir + '/pop.csv', sort_rows=True)
```

[22]:
```
country  gender\time      2013      2014      2015
Belgium       Female   5665118   5687048   5713206
Belgium         Male   5472856   5493792   5524068
 France       Female  33827685  34005671  34280951
 France         Male  31772665  31936596  32175328
Germany       Female  41142770  41210540  41362080
Germany         Male  39380976  39556923  39835457
```

[23]:
```
read_excel(filepath_excel, sheet='births', sort_rows=True)
```

[23]:
```
country  gender\time    2013    2014    2015
Belgium       Female   61235   60841   59713
Belgium         Male   64371   64173   62561
 France       Female  396581  400607  390526
```

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```
 France        Male  415762  418721  409145
Germany      Female  332249  348092  359097
Germany        Male  349820  366835  378478
```

[24]:
```
read_hdf(filepath_hdf, key='deaths', sort_rows=True)
```

[24]:
```
country  gender\time    2013    2014    2015
Belgium       Female   55426   53176   56910
Belgium         Male   53908   51579   53631
 France       Female  281955  277054  296779
 France         Male  287410  282381  297028
Germany       Female  464180  446131  475688
Germany         Male  429645  422225  449512
```

Metadata (HDF5)

Since the version 0.29 of LArray, it is possible to add metadata to arrays:

[25]:
```
pop.meta.title = 'Population at 1st January'
pop.meta.origin = 'Table demo_jpan from Eurostat'

pop.info
```

[25]:
```
title: Population at 1st January
origin: Table demo_jpan from Eurostat
3 x 2 x 3
 country [3]: 'Belgium' 'France' 'Germany'
 gender [2]: 'Male' 'Female'
 time [3]: 2013 2014 2015
dtype: int64
memory used: 144 bytes
```

These metadata are automatically saved and loaded when working with the HDF5 file format:

[26]:
```
pop.to_hdf('population.h5', 'pop')

new_pop = read_hdf('population.h5', 'pop')
new_pop.info
```

[26]:
```
title: Population at 1st January
origin: Table demo_jpan from Eurostat
3 x 2 x 3
 country [3]: 'Belgium' 'France' 'Germany'
 gender [2]: 'Male' 'Female'
 time [3]: 2013 2014 2015
dtype: int64
memory used: 144 bytes
```

Warning: Currently, metadata associated with arrays cannot be saved and loaded when working with CSV and Excel files. This restriction does not apply however to metadata associated with sessions.

Loading and Dumping Sessions

One of the main advantages of grouping arrays, axes and groups in session objects is that you can load and save all of them in one shot. Like arrays, it is possible to associate metadata to a session. These can be saved and loaded in all file formats.

Loading Sessions (CSV, Excel, HDF5)

To load the items of a session, you have two options:

1) Instantiate a new session and pass the path to the Excel/HDF5 file or to the directory containing CSV files to the Session constructor:

[27]:
```
# create a new Session object and load all arrays, axes, groups and metadata
# from all CSV files located in the passed directory
csv_dir = get_example_filepath('population_session')
session = Session(csv_dir)

# create a new Session object and load all arrays, axes, groups and metadata
# stored in the passed Excel file
filepath_excel = get_example_filepath('population_session.xlsx')
session = Session(filepath_excel)

# create a new Session object and load all arrays, axes, groups and metadata
# stored in the passed HDF5 file
filepath_hdf = get_example_filepath('population_session.h5')
session = Session(filepath_hdf)

print(session.summary())
```

```
country: country ['Belgium' 'France' 'Germany'] (3)
gender: gender ['Male' 'Female'] (2)
time: time [2013 2014 2015] (3)
even_years: time['2014'] » even_years (1)
odd_years: time[2013 2015] » odd_years (2)
births: country, gender, time (3 x 2 x 3) [int32]
deaths: country, gender, time (3 x 2 x 3) [int32]
pop: country, gender, time (3 x 2 x 3) [int32]
```

2) Call the `load` method on an existing session and pass the path to the Excel/HDF5 file or to the directory containing CSV files as first argument:

[28]:
```
# create a session containing 3 axes, 2 groups and one array 'pop'
filepath = get_example_filepath('pop_only.xlsx')
session = Session(filepath)

print(session.summary())
```

```
country: country ['Belgium' 'France' 'Germany'] (3)
gender: gender ['Male' 'Female' nan] (3)
time: time [2013 2014 2015] (3)
even_years: time[ 2014.    nan] » even_years (2)
odd_years: time[2013 2015] » odd_years (2)
pop: country, gender, time (3 x 2 x 3) [int64]
```

```
[29]: # call the load method on the previous session and add the 'births' and 'deaths'␣
      ↪arrays to it
      filepath = get_example_filepath('births_and_deaths.xlsx')
      session.load(filepath)

      print(session.summary())
```

```
country: country ['Belgium' 'France' 'Germany'] (3)
gender: gender ['Male' 'Female' nan] (3)
time: time [2013 2014 2015] (3)
even_years: time[ 2014.    nan] » even_years (2)
odd_years: time[2013 2015] » odd_years (2)
pop: country, gender, time (3 x 2 x 3) [int64]
births: country, gender, time (3 x 2 x 3) [int64]
deaths: country, gender, time (3 x 2 x 3) [int64]
```

The `load` method offers some options:

1) Using the `names` argument, you can specify which items to load:

```
[30]: session = Session()

      # use the names argument to only load births and deaths arrays
      session.load(filepath_hdf, names=['births', 'deaths'])

      print(session.summary())
```

```
births: country, gender, time (3 x 2 x 3) [int32]
deaths: country, gender, time (3 x 2 x 3) [int32]
```

2) Setting the `display` argument to True, the `load` method will print a message each time a new item is loaded:

```
[31]: session = Session()

      # with display=True, the load method will print a message
      # each time a new item is loaded
      session.load(filepath_hdf, display=True)
```

```
opening /home/docs/checkouts/readthedocs.org/user_builds/larray-test/conda/
↪documentation/lib/python3.6/site-packages/larray-0.31.dev0-py3.6.egg/larray/tests/
↪data/population_session.h5
loading Axis object country ... done
loading Axis object gender ... done
loading Axis object time ... done
loading Group object even_years ... done
loading Group object odd_years ... done
loading Array object births ... done
loading Array object deaths ... done
loading Array object pop ... done
```

Dumping Sessions (CSV, Excel, HDF5)

To save a session, you need to call the `save` method. The first argument is the path to a Excel/HDF5 file or to a directory if items are saved to CSV files:

```
[32]: # save items of a session in CSV files.
      # Here, the save method will create a 'population' directory in which CSV files will␣
      ↪be written
```

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```
session.save('population')

# save session to an HDF5 file
session.save('population.h5')

# save session to an Excel file
session.save('population.xlsx')

# load session saved in 'population.h5' to see its content
Session('population.h5')
```

[32]:
```
Session(country, gender, time, even_years, odd_years, births, deaths, pop)
```

Note: Concerning the CSV and Excel formats:

- all Axis objects are saved together in the same Excel sheet (CSV file) named `__axes__(.csv)`
  - all Group objects are saved together in the same Excel sheet (CSV file) named `__groups__(.csv)`
  - metadata is saved in one Excel sheet (CSV file) named `__metadata__(.csv)`

  These sheet (CSV file) names cannot be changed.

The `save` method has several arguments:

1) Using the `names` argument, you can specify which items to save:

[33]:
```
# use the names argument to only save births and deaths arrays
session.save('population.h5', names=['births', 'deaths'])

# load session saved in 'population.h5' to see its content
Session('population.h5')
```

[33]:
```
Session(births, deaths)
```

2) By default, dumping a session to an Excel or HDF5 file will overwrite it. By setting the `overwrite` argument to False, you can choose to update the existing Excel or HDF5 file:

[34]:
```
pop = read_csv('./population/pop.csv')
ses_pop = Session([('pop', pop)])

# by setting overwrite to False, the destination file is updated instead of␣
↪overwritten.
# The items already stored in the file but not present in the session are left intact.
# On the contrary, the items that exist in both the file and the session are␣
↪completely overwritten.
ses_pop.save('population.h5', overwrite=False)

# load session saved in 'population.h5' to see its content
Session('population.h5')
```

[34]:
```
Session(births, deaths, pop)
```

3) Setting the `display` argument to True, the `save` method will print a message each time an item is dumped:

[35]:
```
# with display=True, the save method will print a message
# each time an item is dumped
session.save('population.h5', display=True)
```

```
dumping country ... done
dumping gender ... done
dumping time ... done
dumping even_years ... done
dumping odd_years ... done
dumping births ... done
dumping deaths ... done
dumping pop ... done
```

4.2.4 Transforming Arrays (Relabeling, Renaming, Reordering, Combining, Extending, Sorting, . . .)

Import the LArray library:

[2]:
```
from larray import *
```

Check the version of LArray:

[3]:
```
from larray import __version__
__version__
```

[3]:
```
'0.31-dev'
```

Manipulating axes

[4]:
```
# let's start with
pop = load_example_data('demography').pop[2016, 'BruCap', 90:95]
pop
```

[4]:
```
age  sex\nat    BE   FO
 90        M   539   74
 90        F  1477  136
 91        M   499   49
 91        F  1298  105
 92        M   332   35
 92        F  1141   78
 93        M   287   27
 93        F   906   74
 94        M   237   23
 94        F   739   65
 95        M   154   19
 95        F   566   53
```

Relabeling

Replace all labels of one axis

[5]:
```
# returns a copy by default
pop_new_labels = pop.set_labels('sex', ['Men', 'Women'])
pop_new_labels
```

[5]:
```
age  sex\nat    BE   FO
 90      Men   539   74
 90    Women  1477  136
 91      Men   499   49
 91    Women  1298  105
 92      Men   332   35
 92    Women  1141   78
 93      Men   287   27
 93    Women   906   74
 94      Men   237   23
 94    Women   739   65
 95      Men   154   19
 95    Women   566   53
```

[6]:
```
# inplace flag avoids to create a copy
pop.set_labels('sex', ['M', 'F'], inplace=True)
```

[6]:
```
age  sex\nat    BE   FO
 90        M   539   74
 90        F  1477  136
 91        M   499   49
 91        F  1298  105
 92        M   332   35
 92        F  1141   78
 93        M   287   27
 93        F   906   74
 94        M   237   23
 94        F   739   65
 95        M   154   19
 95        F   566   53
```

Renaming axes

Rename one axis

[7]:
```
pop.info
```

[7]:
```
6 x 2 x 2
 age [6]: 90 91 92 93 94 95
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
dtype: int64
memory used: 192 bytes
```

[8]:
```
# 'rename' returns a copy of the array
pop2 = pop.rename('sex', 'gender')
pop2
```

[8]:
```
age  gender\nat    BE   FO
 90           M   539   74
 90           F  1477  136
 91           M   499   49
 91           F  1298  105
 92           M   332   35
 92           F  1141   78
 93           M   287   27
```

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```
 93          F   906   74
 94          M   237   23
 94          F   739   65
 95          M   154   19
 95          F   566   53
```

Rename several axes at once

```
[9]: # No x. here because sex and nat are keywords and not actual axes
pop2 = pop.rename(sex='gender', nat='nationality')
pop2
```

```
[9]: age  gender\nationality    BE   FO
 90                      M   539   74
 90                      F  1477  136
 91                      M   499   49
 91                      F  1298  105
 92                      M   332   35
 92                      F  1141   78
 93                      M   287   27
 93                      F   906   74
 94                      M   237   23
 94                      F   739   65
 95                      M   154   19
 95                      F   566   53
```

Reordering axes

Axes can be reordered using `transpose` method. By default, *transpose* reverse axes, otherwise it permutes the axes according to the list given as argument. Axes not mentioned come after those which are mentioned(and keep their relative order). Finally, *transpose* returns a copy of the array.

```
[10]: # starting order : age, sex, nat
pop
```

```
[10]: age  sex\nat    BE   FO
 90         M   539   74
 90         F  1477  136
 91         M   499   49
 91         F  1298  105
 92         M   332   35
 92         F  1141   78
 93         M   287   27
 93         F   906   74
 94         M   237   23
 94         F   739   65
 95         M   154   19
 95         F   566   53
```

```
[11]: # no argument --> reverse axes
pop.transpose()

# .T is a shortcut for .transpose()
pop.T
```

[11]:
```
nat  sex\age    90    91    92   93   94   95
 BE        M   539   499   332  287  237  154
 BE        F  1477  1298  1141  906  739  566
 FO        M    74    49    35   27   23   19
 FO        F   136   105    78   74   65   53
```

[12]:
```
# reorder according to list
pop.transpose('age', 'nat', 'sex')
```

[12]:
```
age  nat\sex    M     F
 90       BE  539  1477
 90       FO   74   136
 91       BE  499  1298
 91       FO   49   105
 92       BE  332  1141
 92       FO   35    78
 93       BE  287   906
 93       FO   27    74
 94       BE  237   739
 94       FO   23    65
 95       BE  154   566
 95       FO   19    53
```

[13]:
```
# axes not mentioned come after those which are mentioned (and keep their relative␣
↪order)
pop.transpose('sex')
```

[13]:
```
sex  age\nat    BE   FO
  M       90   539   74
  M       91   499   49
  M       92   332   35
  M       93   287   27
  M       94   237   23
  M       95   154   19
  F       90  1477  136
  F       91  1298  105
  F       92  1141   78
  F       93   906   74
  F       94   739   65
  F       95   566   53
```

Combining arrays

Append/Prepend

Append/prepend one element to an axis of an array

[14]:
```
pop = load_example_data('demography').pop[2016, 'BruCap', 90:95]

# imagine that you have now acces to the number of non-EU foreigners
data = [[25, 54], [15, 33], [12, 28], [11, 37], [5, 21], [7, 19]]
pop_non_eu = LArray(data, pop['FO'].axes)

# you can do something like this
pop = pop.append('nat', pop_non_eu, 'NEU')
pop
```

[14]:
```
age  sex\nat    BE   FO  NEU
 90        M   539   74   25
 90        F  1477  136   54
 91        M   499   49   15
 91        F  1298  105   33
 92        M   332   35   12
 92        F  1141   78   28
 93        M   287   27   11
 93        F   906   74   37
 94        M   237   23    5
 94        F   739   65   21
 95        M   154   19    7
 95        F   566   53   19
```

[15]:
```
# you can also add something at the start of an axis
pop = pop.prepend('sex', pop.sum('sex'), 'B')
pop
```

[15]:
```
age  sex\nat    BE   FO  NEU
 90        B  2016  210   79
 90        M   539   74   25
 90        F  1477  136   54
 91        B  1797  154   48
 91        M   499   49   15
 91        F  1298  105   33
 92        B  1473  113   40
 92        M   332   35   12
 92        F  1141   78   28
 93        B  1193  101   48
 93        M   287   27   11
 93        F   906   74   37
 94        B   976   88   26
 94        M   237   23    5
 94        F   739   65   21
 95        B   720   72   26
 95        M   154   19    7
 95        F   566   53   19
```

The value being appended/prepended can have missing (or even extra) axes as long as common axes are compatible

[16]:
```
aliens = zeros(pop.axes['sex'])
aliens
```

[16]:
```
sex    B    M    F
     0.0  0.0  0.0
```

[17]:
```
pop = pop.append('nat', aliens, 'AL')
pop
```

[17]:
```
age  sex\nat      BE     FO   NEU   AL
 90        B  2016.0  210.0  79.0  0.0
 90        M   539.0   74.0  25.0  0.0
 90        F  1477.0  136.0  54.0  0.0
 91        B  1797.0  154.0  48.0  0.0
 91        M   499.0   49.0  15.0  0.0
 91        F  1298.0  105.0  33.0  0.0
 92        B  1473.0  113.0  40.0  0.0
 92        M   332.0   35.0  12.0  0.0
```

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```
 92        F  1141.0   78.0  28.0  0.0
 93        B  1193.0  101.0  48.0  0.0
 93        M   287.0   27.0  11.0  0.0
 93        F   906.0   74.0  37.0  0.0
 94        B   976.0   88.0  26.0  0.0
 94        M   237.0   23.0   5.0  0.0
 94        F   739.0   65.0  21.0  0.0
 95        B   720.0   72.0  26.0  0.0
 95        M   154.0   19.0   7.0  0.0
 95        F   566.0   53.0  19.0  0.0
```

Extend

Extend an array along an axis with another array *with* that axis (but other labels)

[18]:
```
_pop = load_example_data('demography').pop
pop = _pop[2016, 'BruCap', 90:95]
pop_next = _pop[2016, 'BruCap', 96:100]

# concatenate along age axis
pop.extend('age', pop_next)
```

[18]:
```
age  sex\nat    BE   FO
 90        M   539   74
 90        F  1477  136
 91        M   499   49
 91        F  1298  105
 92        M   332   35
 92        F  1141   78
 93        M   287   27
 93        F   906   74
 94        M   237   23
 94        F   739   65
 95        M   154   19
 95        F   566   53
 96        M    80    9
 96        F   327   25
 97        M    43    9
 97        F   171   21
 98        M    23    4
 98        F   135    9
 99        M    20    2
 99        F    92    8
100        M    12    0
100        F    60    3
```

Stack

Stack several arrays together to create an entirely new dimension

[19]:
```
# imagine you have loaded data for each nationality in different arrays (e.g. loaded␣
↪from different Excel sheets)
pop_be, pop_fo = pop['BE'], pop['FO']
```

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```
# first way to stack them
nat = Axis('nat=BE,FO,NEU')
pop = stack([pop_be, pop_fo, pop_non_eu], nat)

# second way
pop = stack([('BE', pop_be), ('FO', pop_fo), ('NEU', pop_non_eu)], 'nat')

pop
```

[19]:
```
age  sex\nat    BE   FO  NEU
 90        M   539   74   25
 90        F  1477  136   54
 91        M   499   49   15
 91        F  1298  105   33
 92        M   332   35   12
 92        F  1141   78   28
 93        M   287   27   11
 93        F   906   74   37
 94        M   237   23    5
 94        F   739   65   21
 95        M   154   19    7
 95        F   566   53   19
```

Sorting

Sort an axis (alphabetically if labels are strings)

[20]:
```
pop_sorted = pop.sort_axes('nat')
pop_sorted
```

[20]:
```
age  sex\nat    BE   FO  NEU
 90        M   539   74   25
 90        F  1477  136   54
 91        M   499   49   15
 91        F  1298  105   33
 92        M   332   35   12
 92        F  1141   78   28
 93        M   287   27   11
 93        F   906   74   37
 94        M   237   23    5
 94        F   739   65   21
 95        M   154   19    7
 95        F   566   53   19
```

Give labels which would sort the axis

[21]:
```
pop_sorted.labelsofsorted('sex')
```

[21]:
```
age  sex\nat  BE  FO  NEU
 90        0   M   M    M
 90        1   F   F    F
 91        0   M   M    M
 91        1   F   F    F
 92        0   M   M    M
 92        1   F   F    F
```

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```
 93        0   M   M    M
 93        1   F   F    F
 94        0   M   M    M
 94        1   F   F    F
 95        0   M   M    M
 95        1   F   F    F
```

Sort according to values

[22]:
```
pop_sorted.sort_values((90, 'F'))
```

[22]:
```
age  sex\nat  NEU   FO    BE
 90        M   25   74   539
 90        F   54  136  1477
 91        M   15   49   499
 91        F   33  105  1298
 92        M   12   35   332
 92        F   28   78  1141
 93        M   11   27   287
 93        F   37   74   906
 94        M    5   23   237
 94        F   21   65   739
 95        M    7   19   154
 95        F   19   53   566
```

4.2.5 Indexing, Selecting and Assigning

Import the LArray library:

[2]:
```
from larray import *
```

Check the version of LArray:

[3]:
```
from larray import __version__
__version__
```

[3]:
```
'0.31-dev'
```

Import the test array pop:

[4]:
```
# let's start with
pop = load_example_data('demography').pop
pop
```

[4]:
```
time     geo  age  sex\nat    BE    FO
1991  BruCap    0        M  4182  2377
1991  BruCap    0        F  4052  2188
1991  BruCap    1        M  3904  2316
1991  BruCap    1        F  3769  2241
1991  BruCap    2        M  3790  2365
 ...     ...  ...      ...   ...   ...
2016     Wal  118        F     0     0
2016     Wal  119        M     0     0
2016     Wal  119        F     0     0
2016     Wal  120        M     0     0
2016     Wal  120        F     0     0
```

Selecting (Subsets)

LArray allows to select a subset of an array either by labels or indices (positions)

Selecting by Labels

To take a subset of an array using labels, use brackets [ ].

Let's start by selecting a single element:

```
[5]: # here we select the value associated with Belgian women
     # of age 50 from Brussels region for the year 2015
     pop[2015, 'BruCap', 50, 'F', 'BE']
```

```
[5]: 4813
```

Continue with selecting a subset using slices and lists of labels

```
[6]: # here we select the subset associated with Belgian women of age 50, 51 and 52
     # from Brussels region for the years 2010 to 2016
     pop[2010:2016, 'BruCap', 50:52, 'F', 'BE']
```

```
[6]: time\age    50    51    52
         2010  4869  4811  4699
         2011  5015  4860  4792
         2012  4722  5014  4818
         2013  4711  4727  5007
         2014  4788  4702  4730
         2015  4813  4767  4676
         2016  4814  4792  4740
```

```
[7]: # slices bounds are optional:
     # if not given start is assumed to be the first label and stop is the last one.
     # Here we select all years starting from 2010
     pop[2010:, 'BruCap', 50:52, 'F', 'BE']
```

```
[7]: time\age    50    51    52
         2010  4869  4811  4699
         2011  5015  4860  4792
         2012  4722  5014  4818
         2013  4711  4727  5007
         2014  4788  4702  4730
         2015  4813  4767  4676
         2016  4814  4792  4740
```

```
[8]: # Slices can also have a step (defaults to 1), to take every Nth labels
     # Here we select all even years starting from 2010
     pop[2010::2, 'BruCap', 50:52, 'F', 'BE']
```

```
[8]: time\age    50    51    52
         2010  4869  4811  4699
         2012  4722  5014  4818
         2014  4788  4702  4730
         2016  4814  4792  4740
```

```
[9]: # one can also use list of labels to take non-contiguous labels.
     # Here we select years 2008, 2010, 2013 and 2015
     pop[[2008, 2010, 2013, 2015], 'BruCap', 50:52, 'F', 'BE']
```

```
[9]: time\age    50    51    52
         2008  4731  4735  4724
         2010  4869  4811  4699
         2013  4711  4727  5007
         2015  4813  4767  4676
```

The order of indexing does not matter either, so you usually do not care/have to remember about axes positions during computation. It only matters for output.

```
[10]: # order of index doesn't matter
pop['F', 'BE', 'BruCap', [2008, 2010, 2013, 2015], 50:52]
```

```
[10]: time\age    50    51    52
          2008  4731  4735  4724
          2010  4869  4811  4699
          2013  4711  4727  5007
          2015  4813  4767  4676
```

Warning: Selecting by labels as above works well as long as there is no ambiguity. When two or more axes have common labels, it may lead to a crash. The solution is then to precise to which axis belong the labels.

```
[11]: # let us now create an array with the same labels on several axes
age, weight, size = Axis('age=0..80'), Axis('weight=0..120'), Axis('size=0..200')

arr_ws = ndtest([age, weight, size])
```

```
[12]: # let's try to select teenagers with size between 1 m 60 and 1 m 65 and weight > 80␣
↪kg.
# In this case the subset is ambiguous and this results in an error:
arr_ws[10:18, :80, 160:165]
```

```
---------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-12-139cd48d3ba8> in <module>
      1 # let's try to select teenagers with size between 1 m 60 and 1 m 65 and␣
↪weight > 80 kg.
      2 # In this case the subset is ambiguous and this results in an error:
----> 3 arr_ws[10:18, :80, 160:165]

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/array.py in __getitem__(self,␣
↪key, collapse_slices, translate_key)
   2088         # FIXME: I have a huge problem with boolean axis labels + non points
   2089         raw_broadcasted_key, res_axes, transpose_indices = self.axes.
↪_key_to_raw_and_axes(key, collapse_slices,
-> 2090                                                                                          ␣
↪              translate_key)
   2091         res_data = data[raw_broadcasted_key]
   2092         if res_axes:

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_key_to_raw_and_axes(self, key, collapse_slices, translate_key)
   2806
   2807         if translate_key:
```

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```
-> 2808                key = self._translated_key(key)
   2809            assert isinstance(key, tuple) and len(key) == self.ndim
   2810

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_translated_key(self, key)
   2766            """
   2767            # any key -> (IGroup, IGroup, ...)
-> 2768            igroup_key = self._key_to_igroups(key)
   2769
   2770            # extract axis from Group keys

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_key_to_igroups(self, key)
   2746
   2747            # translate all keys to IGroup
-> 2748            return tuple(self._translate_axis_key(axis_key) for axis_key in key)
   2749
   2750        def _translated_key(self, key):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in <genexpr>(.0)
   2746
   2747            # translate all keys to IGroup
-> 2748            return tuple(self._translate_axis_key(axis_key) for axis_key in key)
   2749
   2750        def _translated_key(self, key):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_translate_axis_key(self, axis_key)
   2686                return self._translate_axis_key_chunk(axis_key)
   2687            else:
-> 2688                return self._translate_axis_key_chunk(axis_key)
   2689
   2690        def _key_to_igroups(self, key):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_translate_axis_key_chunk(self, axis_key)
   2618                valid_axes = ', '.join(a.name if a.name is not None else '{{{}}}'.
↪format(self.index(a))
   2619                                       for a in valid_axes)
-> 2620                raise ValueError('%s is ambiguous (valid in %s)' % (axis_key,␣
↪valid_axes))
   2621            return valid_axes[0].i[axis_pos_key]
   2622

ValueError: slice(10, 18, None) is ambiguous (valid in age, weight, size)
```

[13]:
```
# the solution is simple. You need to precise the axes on which you make a selection
arr_ws[age[10:18], weight[:80], size[160:165]]
```

[13]:
```
age  weight\size     160     161     162     163     164     165
 10            0  243370  243371  243372  243373  243374  243375
```

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```
 10            1  243571  243572  243573  243574  243575  243576
 10            2  243772  243773  243774  243775  243776  243777
 10            3  243973  243974  243975  243976  243977  243978
 10            4  244174  244175  244176  244177  244178  244179
...          ...     ...     ...     ...     ...     ...     ...
 18           76  453214  453215  453216  453217  453218  453219
 18           77  453415  453416  453417  453418  453419  453420
 18           78  453616  453617  453618  453619  453620  453621
 18           79  453817  453818  453819  453820  453821  453822
 18           80  454018  454019  454020  454021  454022  454023
```

Ambiguous Cases - Specifying Axes Using The Special Variable X

When selecting, assiging or using aggregate functions, an axis can be refered via the special variable `X`:

- pop[X.age[:20]]
- pop.sum(X.age)

This gives you acces to axes of the array you are manipulating. The main drawback of using `X` is that you lose the autocompletion available from many editors. It only works with non-anonymous axes for which names do not contain whitespaces or special characters.

[14]:
```
# the previous example could have been also written as
arr_ws[X.age[10:18], X.weight[:80], X.size[160:165]]
```

[14]:
```
age  weight\size     160     161     162     163     164     165
 10            0  243370  243371  243372  243373  243374  243375
 10            1  243571  243572  243573  243574  243575  243576
 10            2  243772  243773  243774  243775  243776  243777
 10            3  243973  243974  243975  243976  243977  243978
 10            4  244174  244175  244176  244177  244178  244179
...          ...     ...     ...     ...     ...     ...     ...
 18           76  453214  453215  453216  453217  453218  453219
 18           77  453415  453416  453417  453418  453419  453420
 18           78  453616  453617  453618  453619  453620  453621
 18           79  453817  453818  453819  453820  453821  453822
 18           80  454018  454019  454020  454021  454022  454023
```

Selecting by Indices

Sometimes it is more practical to use indices (positions) along the axis, instead of labels. You need to add the character `i` before the brackets: `.i[indices]`. As for selection with labels, you can use a single index, a slice or a list of indices. Indices can be also negative (-1 represent the last element of an axis).

Note: Remember that indices (positions) are always **0-based** in Python. So the first element is at index 0, the second is at index 1, etc.

[15]:
```
# here we select the subset associated with Belgian women of age 50, 51 and 52
# from Brussels region for the first 3 years
pop[X.time.i[:3], 'BruCap', 50:52, 'F', 'BE']
```

[15]:
```
time\age    50    51    52
    1991  3739  4138  4101
    1992  3373  3665  4088
    1993  3648  3335  3615
```

[16]:
```
# same but for the last 3 years
pop[X.time.i[-3:], 'BruCap', 50:52, 'F', 'BE']
```

[16]:
```
time\age    50    51    52
    2014  4788  4702  4730
    2015  4813  4767  4676
    2016  4814  4792  4740
```

[17]:
```
# using list of indices
pop[X.time.i[-9,-7,-4,-2], 'BruCap', 50:52, 'F', 'BE']
```

[17]:
```
time\age    50    51    52
    2008  4731  4735  4724
    2010  4869  4811  4699
    2013  4711  4727  5007
    2015  4813  4767  4676
```

Warning: The end *indice* (position) is EXCLUSIVE while the end label is INCLUSIVE.

[18]:
```
# with labels (3 is included)
pop[2015, 'BruCap', X.age[:3], 'F', 'BE']
```

[18]:
```
age     0     1     2     3
     6020  5882  6023  5861
```

[19]:
```
# with indices (3 is out)
pop[2015, 'BruCap', X.age.i[:3], 'F', 'BE']
```

[19]:
```
age     0     1     2
     6020  5882  6023
```

You can use `.i[]` selection directly on array instead of axes. In this context, if you want to select a subset of the first and third axes for example, you must use a full slice `:` for the second one.

[20]:
```
# here we select the last year and first 3 ages
# equivalent to: pop.i[-1, :, :3, :, :]
pop.i[-1, :, :3]
```

[20]:
```
   geo  age  sex\nat     BE    FO
BruCap    0        M   6155  3104
BruCap    0        F   5900  2817
BruCap    1        M   6165  3068
BruCap    1        F   5916  2946
BruCap    2        M   6053  2918
BruCap    2        F   5736  2776
   Fla    0        M  29993  3717
   Fla    0        F  28483  3587
   Fla    1        M  31292  3716
   Fla    1        F  29721  3575
   Fla    2        M  31718  3597
   Fla    2        F  30353  3387
```

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```
  Wal    0         M  17869  1472
  Wal    0         F  17242  1454
  Wal    1         M  18820  1432
  Wal    1         F  17604  1443
  Wal    2         M  19076  1444
  Wal    2         F  18189  1358
```

Using Groups In Selections

[21]:
```
teens = pop.age[10:20]

pop[2015, 'BruCap', teens, 'F', 'BE']
```

[21]:
```
age    10    11    12    13    14    15    16    17    18    19    20
     5124  4865  4758  4807  4587  4593  4429  4466  4517  4461  4464
```

Assigning subsets

Assigning A Value

Assign a value to a subset

[22]:
```
# let's take a smaller array
pop = load_example_data('demography').pop[2016, 'BruCap', 100:105]
pop2 = pop
pop2
```

[22]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
101        M  12   2
101        F  66   5
102        M   8   0
102        F  26   1
103        M   2   1
103        F  17   2
104        M   2   1
104        F  14   0
105        M   0   0
105        F   2   2
```

[23]:
```
# set all data corresponding to age >= 102 to 0
pop2[102:] = 0
pop2
```

[23]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
101        M  12   2
101        F  66   5
102        M   0   0
102        F   0   0
103        M   0   0
```

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```
103         F    0    0
104         M    0    0
104         F    0    0
105         M    0    0
105         F    0    0
```

One very important gotcha though…

Warning: Modifying a slice of an array in-place like we did above should be done with care otherwise you could have **unexpected effects**. The reason is that taking a **slice** subset of an array does not return a copy of that array, but rather a view on that array. To avoid such behavior, use `.copy()` method.

Remember:

- taking a slice subset of an array is extremely fast (no data is copied)
- if one modifies that subset in-place, one also **modifies the original array**
- **.copy()** returns a copy of the subset (takes speed and memory) but allows you to change the subset without modifying the original array in the same time

[24]:
```
# indeed, data from the original array have also changed
pop
```

[24]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
101        M  12   2
101        F  66   5
102        M   0   0
102        F   0   0
103        M   0   0
103        F   0   0
104        M   0   0
104        F   0   0
105        M   0   0
105        F   0   0
```

[25]:
```
# the right way
pop = load_example_data('demography').pop[2016, 'BruCap', 100:105]

pop2 = pop.copy()
pop2[102:] = 0
pop2
```

[25]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
101        M  12   2
101        F  66   5
102        M   0   0
102        F   0   0
103        M   0   0
103        F   0   0
104        M   0   0
104        F   0   0
```

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```
105         M    0    0
105         F    0    0
```

[26]:
```
# now, data from the original array have not changed this time
pop
```

[26]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
101        M  12   2
101        F  66   5
102        M   8   0
102        F  26   1
103        M   2   1
103        F  17   2
104        M   2   1
104        F  14   0
105        M   0   0
105        F   2   2
```

Assigning Arrays And Broadcasting

Instead of a value, we can also assign an array to a subset. In that case, that array can have less axes than the target but those which are present must be compatible with the subset being targeted.

[27]:
```
sex, nat = Axis('sex=M,F'), Axis('nat=BE,FO')
new_value = LArray([[1, -1], [2, -2]],[sex, nat])
new_value
```

[27]:
```
sex\nat  BE  FO
      M   1  -1
      F   2  -2
```

[28]:
```
# this assigns 1, -1 to Belgian, Foreigner men
# and 2, -2 to Belgian, Foreigner women for all
# people older than 100
pop[102:] = new_value
pop
```

[28]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
101        M  12   2
101        F  66   5
102        M   1  -1
102        F   2  -2
103        M   1  -1
103        F   2  -2
104        M   1  -1
104        F   2  -2
105        M   1  -1
105        F   2  -2
```

Warning: The array being assigned must have compatible axes (i.e. same axes names and same labels) with the target subset.

[29]:
```
# assume we define the following array with shape 3 x 2 x 2
new_value = zeros(['age=100..102', sex, nat])
new_value
```

[29]:
```
age  sex\nat   BE   FO
100        M  0.0  0.0
100        F  0.0  0.0
101        M  0.0  0.0
101        F  0.0  0.0
102        M  0.0  0.0
102        F  0.0  0.0
```

[30]:
```
# now let's try to assign the previous array in a subset from age 103 to 105
pop[103:105] = new_value
```

```
---------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-30-63d0ef0af080> in <module>
      1 # now let’s try to assign the previous array in a subset from age 103 to 105
---> 2 pop[103:105] = new_value

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/array.py in __setitem__(self,␣
↪key, value, collapse_slices, translate_key)
   2108             # TODO: the check_compatible should be included in broadcast_with
   2109             value = value.broadcast_with(target_axes)
-> 2110             value.axes.check_compatible(target_axes)
   2111
   2112             # replace incomprehensible error message "could not broadcast␣
↪input array from shape XX into shape YY"

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪check_compatible(self, axes)
   1986             local_axis = self.get_by_pos(axis, i)
   1987             if not local_axis.iscompatible(axis):
-> 1988                 raise ValueError("incompatible axes:\n{!r}\nvs\n{!r}".
↪format(axis, local_axis))
   1989
   1990     # XXX: deprecate method (functionality is duplicated in union)?

ValueError: incompatible axes:
Axis([103, 104, 105], ’age’)
vs
Axis([100, 101, 102], ’age’)
```

[31]:
```
# but this works
pop[100:102] = new_value
pop
```

[31]:
```
age  sex\nat  BE  FO
100        M   0   0
100        F   0   0
101        M   0   0
```

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```
101         F   0   0
102         M   0   0
102         F   0   0
103         M   1  -1
103         F   2  -2
104         M   1  -1
104         F   2  -2
105         M   1  -1
105         F   2  -2
```

Boolean Filtering

Boolean filtering can be use to extract subsets.

[32]:
```
#Let's focus on population living in Brussels during the year 2016
pop = load_example_data('demography').pop[2016, 'BruCap']

# here we select all males and females with age less than 5 and 10 respectively
subset = pop[((X.sex == 'H') & (X.age <= 5)) | ((X.sex == 'F') & (X.age <= 10))]
subset
```

[32]:
```
sex_age\nat    BE    FO
        F_0  5900  2817
        F_1  5916  2946
        F_2  5736  2776
        F_3  5883  2734
        F_4  5784  2523
        F_5  5780  2521
        F_6  5759  2290
        F_7  5518  2234
        F_8  5474  2066
        F_9  5354  1896
       F_10  5200  1785
```

Note: Be aware that after boolean filtering, several axes may have merged.

[33]:
```
# 'age' and 'sex' axes have been merged together
subset.info
```

[33]:
```
11 x 2
 sex_age [11]: 'F_0' 'F_1' 'F_2' ... 'F_8' 'F_9' 'F_10'
 nat [2]: 'BE' 'FO'
dtype: int64
memory used: 176 bytes
```

This may be not what you because previous selections on merged axes are no longer valid

[34]:
```
# now let's try to calculate the proportion of females with age less than 10
subset['F'].sum() / pop['F'].sum()
```

```
---------------------------------------------------
ValueError                                  Traceback (most recent call last)
<ipython-input-34-d9f443e5c9e1> in <module>
      1 # now let's try to calculate the proportion of females with age less than 10
```

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```
---> 2 subset['F'].sum() / pop['F'].sum()

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/array.py in __getitem__(self,␣
↪key, collapse_slices, translate_key)
   2088         # FIXME: I have a huge problem with boolean axis labels + non points
   2089         raw_broadcasted_key, res_axes, transpose_indices = self.axes.
↪_key_to_raw_and_axes(key, collapse_slices,
-> 2090                                                                              ␣
↪             translate_key)
   2091         res_data = data[raw_broadcasted_key]
   2092         if res_axes:

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_key_to_raw_and_axes(self, key, collapse_slices, translate_key)
   2806
   2807         if translate_key:
-> 2808             key = self._translated_key(key)
   2809         assert isinstance(key, tuple) and len(key) == self.ndim
   2810

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_translated_key(self, key)
   2766         """
   2767         # any key -> (IGroup, IGroup, ...)
-> 2768         igroup_key = self._key_to_igroups(key)
   2769
   2770         # extract axis from Group keys

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_key_to_igroups(self, key)
   2746
   2747         # translate all keys to IGroup
-> 2748         return tuple(self._translate_axis_key(axis_key) for axis_key in key)
   2749
   2750     def _translated_key(self, key):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in <genexpr>(.0)
   2746
   2747         # translate all keys to IGroup
-> 2748         return tuple(self._translate_axis_key(axis_key) for axis_key in key)
   2749
   2750     def _translated_key(self, key):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_translate_axis_key(self, axis_key)
   2686             return self._translate_axis_key_chunk(axis_key)
   2687         else:
-> 2688             return self._translate_axis_key_chunk(axis_key)
   2689
   2690     def _key_to_igroups(self, key):
```

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```
~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in␣
↪_translate_axis_key_chunk(self, axis_key)
   2612                 continue
   2613         if not valid_axes:
-> 2614             raise ValueError("%s is not a valid label for any axis" %␣
↪axis_key)
   2615         elif len(valid_axes) > 1:
   2616             # TODO: make an AxisCollection.display_name(axis) method out of␣
↪this

ValueError: F is not a valid label for any axis
```

Therefore, it is sometimes more useful to not select, but rather set to 0 (or another value) non matching elements

[35]:
```
subset = pop.copy()
subset[((X.sex == 'F') & (X.age > 10))] = 0
subset['F', :20]
```

[35]:
```
age\nat    BE    FO
      0  5900  2817
      1  5916  2946
      2  5736  2776
      3  5883  2734
      4  5784  2523
      5  5780  2521
      6  5759  2290
      7  5518  2234
      8  5474  2066
      9  5354  1896
     10  5200  1785
     11     0     0
     12     0     0
     13     0     0
     14     0     0
     15     0     0
     16     0     0
     17     0     0
     18     0     0
     19     0     0
     20     0     0
```

[36]:
```
# now we can calculate the proportion of females with age less than 10
subset['F'].sum() / pop['F'].sum()
```

[36]:
```
0.14618110657051941
```

Boolean filtering can also mix axes and arrays. Example above could also have been written as

[37]:
```
age_limit = sequence('sex=M,F', initial=5, inc=5)
age_limit
```

[37]:
```
sex  M   F
     5  10
```

[38]:
```
age = pop.axes['age']
(age <= age_limit)[:20]
```

[38]:
```
age\sex      M      F
      0   True   True
      1   True   True
      2   True   True
      3   True   True
      4   True   True
      5   True   True
      6  False   True
      7  False   True
      8  False   True
      9  False   True
     10  False   True
     11  False  False
     12  False  False
     13  False  False
     14  False  False
     15  False  False
     16  False  False
     17  False  False
     18  False  False
     19  False  False
     20  False  False
```

[39]:
```
subset = pop.copy()
subset[X.age > age_limit] = 0
subset['F'].sum() / pop['F'].sum()
```

[39]:
```
0.14618110657051941
```

Finally, you can choose to filter on data instead of axes

[40]:
```
# let's focus on females older than 90
subset = pop['F', 90:110].copy()
subset
```

[40]:
```
age\nat    BE   FO
     90  1477  136
     91  1298  105
     92  1141   78
     93   906   74
     94   739   65
     95   566   53
     96   327   25
     97   171   21
     98   135    9
     99    92    8
    100    60    3
    101    66    5
    102    26    1
    103    17    2
    104    14    0
    105     2    2
    106     3    3
    107     1    2
    108     1    0
    109     0    0
    110     0    0
```

[41]:
```
# here we set to 0 all data < 10
subset[subset < 10] = 0
subset
```

[41]:
```
age\nat    BE   FO
     90  1477  136
     91  1298  105
     92  1141   78
     93   906   74
     94   739   65
     95   566   53
     96   327   25
     97   171   21
     98   135    0
     99    92    0
    100    60    0
    101    66    0
    102    26    0
    103    17    0
    104    14    0
    105     0    0
    106     0    0
    107     0    0
    108     0    0
    109     0    0
    110     0    0
```

4.2.6 Arithmetic Operations And Aggregations

Import the LArray library:

[2]:
```
from larray import *
```

Check the version of LArray:

[3]:
```
from larray import __version__
__version__
```

[3]:
```
'0.31-dev'
```

Arithmetic operations

Import a subset of the test array `pop`:

[4]:
```
# import a 6 x 2 x 2 subset of the 'pop' example array
pop = load_example_data('demography').pop[2016, 'BruCap', 90:95]
pop
```

[4]:
```
age  sex\nat    BE   FO
 90        M   539   74
 90        F  1477  136
 91        M   499   49
 91        F  1298  105
 92        M   332   35
 92        F  1141   78
```

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```
 93         M   287   27
 93         F   906   74
 94         M   237   23
 94         F   739   65
 95         M   154   19
 95         F   566   53
```

One can do all usual arithmetic operations on an array, it will apply the operation to all elements individually

[5]:
```
# addition
pop + 200
```

[5]:
```
age  sex\nat    BE   FO
 90         M   739  274
 90         F  1677  336
 91         M   699  249
 91         F  1498  305
 92         M   532  235
 92         F  1341  278
 93         M   487  227
 93         F  1106  274
 94         M   437  223
 94         F   939  265
 95         M   354  219
 95         F   766  253
```

[6]:
```
# multiplication
pop * 2
```

[6]:
```
age  sex\nat    BE   FO
 90         M  1078  148
 90         F  2954  272
 91         M   998   98
 91         F  2596  210
 92         M   664   70
 92         F  2282  156
 93         M   574   54
 93         F  1812  148
 94         M   474   46
 94         F  1478  130
 95         M   308   38
 95         F  1132  106
```

[7]:
```
# ** means raising to the power (squaring in this case)
pop ** 2
```

[7]:
```
age  sex\nat       BE     FO
 90         M   290521   5476
 90         F  2181529  18496
 91         M   249001   2401
 91         F  1684804  11025
 92         M   110224   1225
 92         F  1301881   6084
 93         M    82369    729
 93         F   820836   5476
 94         M    56169    529
 94         F   546121   4225
```

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```
 95         M    23716    361
 95         F   320356   2809
```

[8]:
```
# % means modulo (aka remainder of division)
pop % 10
```

[8]:
```
age  sex\nat  BE  FO
 90        M   9   4
 90        F   7   6
 91        M   9   9
 91        F   8   5
 92        M   2   5
 92        F   1   8
 93        M   7   7
 93        F   6   4
 94        M   7   3
 94        F   9   5
 95        M   4   9
 95        F   6   3
```

More interestingly, it also works between two arrays

[9]:
```
# load mortality equivalent array
mortality = load_example_data('demography').qx[2016, 'BruCap', 90:95]

# compute number of deaths
death = pop * mortality
death
```

[9]:
```
age  sex\nat                  BE                  FO
 90        M   94.00000000000001  13.000000000000004
 90        F  204.00000000000003  19.000000000000004
 91        M                95.0                 9.0
 91        F  200.00000000000006                16.0
 92        M                70.0                 7.0
 92        F  195.00000000000006  13.000000000000004
 93        M   66.00000000000001                 6.0
 93        F  171.99999999999997                14.0
 94        M                59.0                 6.0
 94        F  155.00000000000003                14.0
 95        M                41.0                 5.0
 95        F               130.0  12.000000000000004
```

Note: Be careful when mixing different data types. You can use the method `astype` to change the data type of an array.

[10]:
```
# to be sure to get number of deaths as integers
# one can use .astype() method
death = (pop * mortality).astype(int)
death
```

[10]:
```
age  sex\nat   BE  FO
 90        M   94  13
 90        F  204  19
 91        M   95   9
```

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```
91          F   200   16
92          M    70    7
92          F   195   13
93          M    66    6
93          F   171   14
94          M    59    6
94          F   155   14
95          M    41    5
95          F   130   12
```

Warning: Operations between two arrays only works when they have compatible axes (i.e. same labels). However, it can be override but at your own risk. In that case only the position on the axis is used and not the labels.

[11]:
```
pop[90:92] * mortality[93:95]
```

```
---------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-11-3e6b95e7cc66> in <module>
---> 1 pop[90:92] * mortality[93:95]

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/array.py in opmethod(self,␣
↪other)
   5439             if isinstance(other, LArray):
   5440                 # TODO: first test if it is not already broadcastable
-> 5441                 (self, other), res_axes = make_numpy_broadcastable([self,␣
↪other])
   5442                 other = other.data
   5443             return LArray(super_method(self.data, other), res_axes)

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/array.py in␣
↪make_numpy_broadcastable(values, min_axes)
   9350     Axis.iscompatible : tests if axes are compatible between them.
   9351     """
-> 9352     all_axes = AxisCollection.union(*[get_axes(v) for v in values])
   9353     if min_axes is not None:
   9354         if not isinstance(min_axes, AxisCollection):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in union(self, *args,␣
↪**kwargs)
   1705             if not isinstance(a, AxisCollection):
   1706                 a = AxisCollection(a)
-> 1707             result.extend(a, validate=validate,␣
↪replace_wildcards=replace_wildcards)
   1708         return result
   1709     __or__ = union

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/axis.py in extend(self, axes,␣
↪validate, replace_wildcards)
   2050                 # check that common axes are the same
   2051                 if validate and not old_axis.iscompatible(axis):
```

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```
-> 2052                     raise ValueError("incompatible axes:\n%r\nvs\n%r" % (axis,
↪ old_axis))
   2053                 if replace_wildcards and old_axis.iswildcard:
   2054                     self[old_axis] = axis

ValueError: incompatible axes:
Axis([93, 94, 95], 'age')
vs
Axis([90, 91, 92], 'age')
```

```
[12]: pop[90:92] * mortality[93:95].ignore_labels('age')
```

```
[12]: age  sex\nat                  BE                  FO
       90        M  123.95121951219514  16.444444444444443
       90        F    280.401766004415   25.72972972972973
       91        M  124.22362869198312  12.782608695652174
       91        F  272.24627875507446  22.615384615384617
       92        M   88.38961038961038   9.210526315789473
       92        F  262.06713780918733   17.66037735849057
```

Boolean Operations

```
[13]: pop2 = pop.copy()
      pop2['F'] = -pop2['F']
      pop2
```

```
[13]: age  sex\nat     BE    FO
       90        M    539    74
       90        F  -1477  -136
       91        M    499    49
       91        F  -1298  -105
       92        M    332    35
       92        F  -1141   -78
       93        M    287    27
       93        F   -906   -74
       94        M    237    23
       94        F   -739   -65
       95        M    154    19
       95        F   -566   -53
```

```
[14]: # testing for equality is done using == (a single = assigns the value)
      pop == pop2
```

```
[14]: age  sex\nat     BE     FO
       90        M   True   True
       90        F  False  False
       91        M   True   True
       91        F  False  False
       92        M   True   True
       92        F  False  False
       93        M   True   True
       93        F  False  False
       94        M   True   True
       94        F  False  False
       95        M   True   True
       95        F  False  False
```

[15]:
```
# testing for inequality
pop != pop2
```

[15]:
```
age  sex\nat     BE     FO
 90        M  False  False
 90        F   True   True
 91        M  False  False
 91        F   True   True
 92        M  False  False
 92        F   True   True
 93        M  False  False
 93        F   True   True
 94        M  False  False
 94        F   True   True
 95        M  False  False
 95        F   True   True
```

[16]:
```
# what was our original array like again?
pop
```

[16]:
```
age  sex\nat    BE   FO
 90        M   539   74
 90        F  1477  136
 91        M   499   49
 91        F  1298  105
 92        M   332   35
 92        F  1141   78
 93        M   287   27
 93        F   906   74
 94        M   237   23
 94        F   739   65
 95        M   154   19
 95        F   566   53
```

[17]:
```
# & means (boolean array) and
(pop >= 500) & (pop <= 1000)
```

[17]:
```
age  sex\nat     BE     FO
 90        M   True  False
 90        F  False  False
 91        M  False  False
 91        F  False  False
 92        M  False  False
 92        F  False  False
 93        M  False  False
 93        F   True  False
 94        M  False  False
 94        F   True  False
 95        M  False  False
 95        F   True  False
```

[18]:
```
# | means (boolean array) or
(pop < 500) | (pop > 1000)
```

[18]:
```
age  sex\nat     BE    FO
 90        M  False  True
 90        F   True  True
 91        M   True  True
```

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```
 91         F   True  True
 92         M   True  True
 92         F   True  True
 93         M   True  True
 93         F  False  True
 94         M   True  True
 94         F  False  True
 95         M   True  True
 95         F  False  True
```

Arithmetic operations with missing axes

[19]:
```
pop.sum('age')
```

[19]:
```
sex\nat    BE   FO
      M  2048  227
      F  6127  511
```

[20]:
```
# arr has 3 dimensions
pop.info
```

[20]:
```
6 x 2 x 2
 age [6]: 90 91 92 93 94 95
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
dtype: int64
memory used: 192 bytes
```

[21]:
```
# and arr.sum(age) has two
pop.sum('age').info
```

[21]:
```
2 x 2
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
dtype: int64
memory used: 32 bytes
```

[22]:
```
# you can do operation with missing axes so this works
pop / pop.sum('age')
```

[22]:
```
age  sex\nat                   BE                   FO
 90        M        0.26318359375  0.32599118942731276
 90        F   0.2410641423208748  0.26614481409001955
 91        M        0.24365234375  0.21585903083700442
 91        F   0.2118491921005386   0.2054794520547945
 92        M          0.162109375  0.15418502202643172
 92        F  0.18622490615309287  0.15264187866927592
 93        M        0.14013671875  0.11894273127753303
 93        F  0.14787008323812634  0.14481409001956946
 94        M        0.11572265625   0.1013215859030837
 94        F  0.12061367716663947  0.12720156555772993
 95        M         0.0751953125  0.08370044052863436
 95        F  0.09237799902072792  0.10371819960861056
```

Axis order does not matter much (except for output)

You can do operations between arrays having different axes order. The axis order of the result is the same as the left array

```
[23]: pop
```

```
[23]: age  sex\nat    BE   FO
       90        M   539   74
       90        F  1477  136
       91        M   499   49
       91        F  1298  105
       92        M   332   35
       92        F  1141   78
       93        M   287   27
       93        F   906   74
       94        M   237   23
       94        F   739   65
       95        M   154   19
       95        F   566   53
```

```
[24]: # let us change the order of axes
      pop_transposed = pop.T
      pop_transposed
```

```
[24]: nat  sex\age    90    91    92   93   94   95
       BE        M   539   499   332  287  237  154
       BE        F  1477  1298  1141  906  739  566
       FO        M    74    49    35   27   23   19
       FO        F   136   105    78   74   65   53
```

```
[25]: # mind blowing
      pop_transposed + pop
```

```
[25]: nat  sex\age    90    91    92    93    94    95
       BE        M  1078   998   664   574   474   308
       BE        F  2954  2596  2282  1812  1478  1132
       FO        M   148    98    70    54    46    38
       FO        F   272   210   156   148   130   106
```

Aggregates

Calculate the sum along an axis:

```
[26]: pop = load_example_data('demography').pop[2016, 'BruCap']
      pop.sum('age')
```

```
[26]: sex\nat      BE      FO
            M  375261  204534
            F  401554  206541
```

or along all axes except one by appending _by to the aggregation function

```
[27]: pop[90:95].sum_by('age')
      # is equivalent to
      pop[90:95].sum('sex', 'nat')
```

[27]:
```
age     90    91    92    93    94   95
      2226  1951  1586  1294  1064  792
```

Calculate the sum along one group:

[28]:
```
teens = pop.age[10:20]

pop.sum(teens)
```

[28]:
```
sex\nat     BE     FO
      M  53834  19145
      F  51740  18871
```

Calculate the sum along two groups:

[29]:
```
pensioners = pop.age[67:]

# groups from the same axis must be grouped in a tuple
pop.sum((teens, pensioners))
```

[29]:
```
  age  sex\nat     BE     FO
10:20        M  53834  19145
10:20        F  51740  18871
  67:        M  44138   9939
  67:        F  70314  13241
```

Mixing axes and groups in aggregations:

[30]:
```
pop.sum((teens, pensioners), 'nat')
```

[30]:
```
age\sex      M      F
  10:20  72979  70611
    67:  54077  83555
```

More On Aggregations

There are many other aggregation functions:

- mean, min, max, median, percentile, var (variance), std (standard deviation)
- labelofmin, labelofmax (label indirect minimum/maxium – labels where the value is minimum/maximum)
- indexofmin, indexofmax (positional indirect minimum/maxium – position along axis where the value is minimum/maximum)
- cumsum, cumprod (cumulative sum, cumulative product)

4.2.7 Plotting

Import the LArray library:

[2]:
```
from larray import *
```

Check the version of LArray:

[3]:
```
from larray import __version__
__version__
```

```
[3]: '0.31-dev'
```

Import a subset of the test array pop:

```
[4]: # import a 6 x 2 x 2 subset of the 'pop' example array
pop = load_example_data('demography').pop[2016, 'BruCap', 90:95]
pop
```

```
[4]: age  sex\nat    BE   FO
      90         M   539   74
      90         F  1477  136
      91         M   499   49
      91         F  1298  105
      92         M   332   35
      92         F  1141   78
      93         M   287   27
      93         F   906   74
      94         M   237   23
      94         F   739   65
      95         M   154   19
      95         F   566   53
```

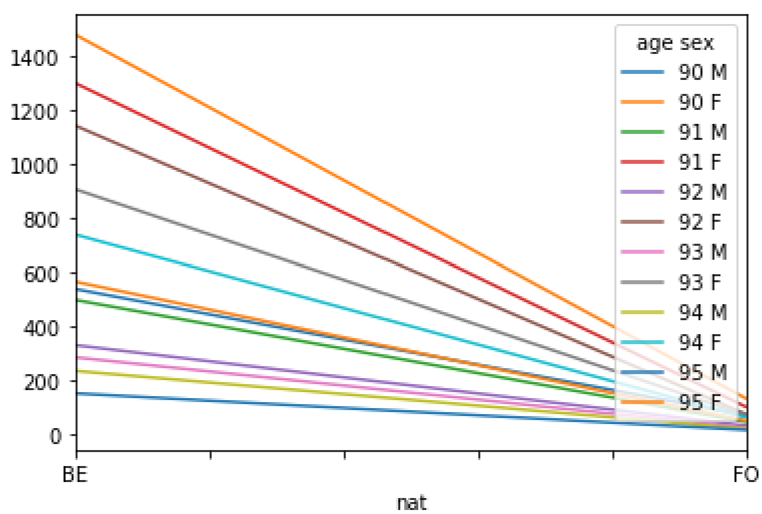
Inline matplotlib:

```
[5]: %matplotlib inline
```

Create a plot (last axis define the different curves to draw):

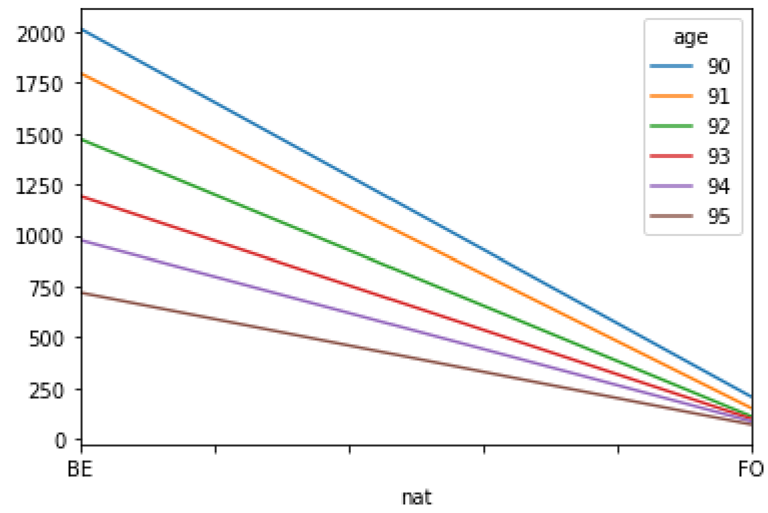
```
[6]: pop.plot()
```

```
[6]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa3f35976a0>
```




```
[7]: # plot total of both sex
pop.sum('sex').plot()
```

```
[7]: <matplotlib.axes._subplots.AxesSubplot at 0x7fa3f145f3c8>
```



4.2.8 Miscellaneous (other interesting array functions)

Import the LArray library:

```
[2]: from larray import *
```

Check the version of LArray:

```
[3]: from larray import __version__
     __version__
```

```
[3]: '0.31-dev'
```

Import a subset of the test array pop:

```
[4]: # import a 6 x 2 x 2 subset of the 'pop' example array
     pop = load_example_data('demography').pop[2016, 'BruCap', 100:105]
     pop
```

```
[4]: age  sex\nat  BE  FO
     100        M  12   0
     100        F  60   3
     101        M  12   2
     101        F  66   5
     102        M   8   0
     102        F  26   1
     103        M   2   1
     103        F  17   2
     104        M   2   1
     104        F  14   0
     105        M   0   0
     105        F   2   2
```

with total

Add totals to one axis

[5]:
```
pop.with_total('sex', label='B')
```

[5]:
```
age  sex\nat  BE  FO
100        M  12   0
100        F  60   3
100        B  72   3
101        M  12   2
101        F  66   5
101        B  78   7
102        M   8   0
102        F  26   1
102        B  34   1
103        M   2   1
103        F  17   2
103        B  19   3
104        M   2   1
104        F  14   0
104        B  16   1
105        M   0   0
105        F   2   2
105        B   2   2
```

Add totals to all axes at once

[6]:
```
# by default label is 'total'
pop.with_total()
```

[6]:
```
  age  sex\nat   BE  FO  total
  100        M   12   0     12
  100        F   60   3     63
  100    total   72   3     75
  101        M   12   2     14
  101        F   66   5     71
  101    total   78   7     85
  102        M    8   0      8
  102        F   26   1     27
  102    total   34   1     35
  103        M    2   1      3
  103        F   17   2     19
  103    total   19   3     22
  104        M    2   1      3
  104        F   14   0     14
  104    total   16   1     17
  105        M    0   0      0
  105        F    2   2      4
  105    total    2   2      4
total        M   36   4     40
total        F  185  13    198
total    total  221  17    238
```

where

where can be used to apply some computation depending on a condition

[7]:
```
# where(condition, value if true, value if false)
where(pop < 10, 0, -pop)
```

```
[7]: age  sex\nat   BE  FO
     100        M  -12   0
     100        F  -60   0
     101        M  -12   0
     101        F  -66   0
     102        M    0   0
     102        F  -26   0
     103        M    0   0
     103        F  -17   0
     104        M    0   0
     104        F  -14   0
     105        M    0   0
     105        F    0   0
```

clip

Set all data between a certain range

```
[8]: # clip(min, max)
     # values below 10 are set to 10 and values above 50 are set to 50
     pop.clip(10, 50)
```

```
[8]: age  sex\nat  BE  FO
     100        M  12  10
     100        F  50  10
     101        M  12  10
     101        F  50  10
     102        M  10  10
     102        F  26  10
     103        M  10  10
     103        F  17  10
     104        M  10  10
     104        F  14  10
     105        M  10  10
     105        F  10  10
```

divnot0

Replace division by 0 to 0

```
[9]: pop['BE'] / pop['FO']
```

```
/home/docs/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/
↪python3.6/site-packages/ipykernel_launcher.py:1: RuntimeWarning: divide by zero␣
↪encountered during operation
  """Entry point for launching an IPython kernel.
/home/docs/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/
↪python3.6/site-packages/ipykernel_launcher.py:1: RuntimeWarning: invalid value␣
↪(NaN) encountered during operation (this is typically caused by a 0 / 0)
  """Entry point for launching an IPython kernel.
```

```
[9]: age\sex    M     F
         100  inf  20.0
         101  6.0  13.2
         102  inf  26.0
         103  2.0   8.5
```

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```
    104  2.0   inf
    105  nan   1.0
```

```
[10]: # divnot0 replaces results of division by 0 by 0.
      # Using it should be done with care though
      # because it can hide a real error in your data.
      pop['BE'].divnot0(pop['FO'])
```

```
[10]: age\sex    M     F
          100  0.0  20.0
          101  6.0  13.2
          102  0.0  26.0
          103  2.0   8.5
          104  2.0   0.0
          105  0.0   1.0
```

diff

The `diff` method calculates the n-th order discrete difference along a given axis. The first order difference is given by out[n+1] = in[n + 1] - in[n] along the given axis.

```
[11]: pop = load_example_data('demography').pop[2005:2015, 'BruCap', 50]
      pop
```

```
[11]: time  sex\nat    BE    FO
      2005        M  4289  1591
      2005        F  4661  1584
      2006        M  4335  1761
      2006        F  4781  1580
      2007        M  4291  1806
      2007        F  4719  1650
      2008        M  4349  1773
      2008        F  4731  1680
      2009        M  4429  2003
      2009        F  4824  1722
      2010        M  4582  2085
      2010        F  4869  1928
      2011        M  4677  2294
      2011        F  5015  2104
      2012        M  4463  2450
      2012        F  4722  2186
      2013        M  4610  2604
      2013        F  4711  2254
      2014        M  4725  2709
      2014        F  4788  2349
      2015        M  4841  2891
      2015        F  4813  2498
```

```
[12]: # calculates 'pop[year+1] - pop[year]'
      pop.diff('time')
```

```
[12]: time  sex\nat    BE   FO
      2006        M    46  170
      2006        F   120   -4
      2007        M   -44   45
      2007        F   -62   70
```

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```
2008         M    58  -33
2008         F    12   30
2009         M    80  230
2009         F    93   42
2010         M   153   82
2010         F    45  206
2011         M    95  209
2011         F   146  176
2012         M  -214  156
2012         F  -293   82
2013         M   147  154
2013         F   -11   68
2014         M   115  105
2014         F    77   95
2015         M   116  182
2015         F    25  149
```

[13]:
```
# calculates 'pop[year+2] - pop[year]'
pop.diff('time', d=2)
```

[13]:
```
time  sex\nat    BE   FO
2007         M     2  215
2007         F    58   66
2008         M    14   12
2008         F   -50  100
2009         M   138  197
2009         F   105   72
2010         M   233  312
2010         F   138  248
2011         M   248  291
2011         F   191  382
2012         M  -119  365
2012         F  -147  258
2013         M   -67  310
2013         F  -304  150
2014         M   262  259
2014         F    66  163
2015         M   231  287
2015         F   102  244
```

ratio

[14]:
```
pop.ratio('nat')

# which is equivalent to
pop / pop.sum('nat')
```

[14]:
```
time  sex\nat                  BE                   FO
2005         M   0.729421768707483   0.270578231292517
2005         F  0.7463570856685349  0.2536429143314652
2006         M  0.7111220472440944  0.2888779527559055
2006         F  0.7516113818581984  0.2483886181418016
2007         M   0.703788748564868  0.29621125143513205
2007         F  0.7409326424870466  0.25906735751295334
2008         M  0.7103887618425351  0.28961123815746487
```

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```
2008         F  0.7379503977538605  0.26204960224613943
2009         M  0.6885883084577115  0.31141169154228854
2009         F  0.7369385884509624  0.26306141154903756
2010         M  0.6872656367181641   0.3127343632818359
2010         F  0.7163454465205238   0.2836545534794762
2011         M  0.6709223927700474  0.32907760722995266
2011         F  0.7044528725944655  0.29554712740553446
2012         M  0.6455952553160712  0.35440474468392885
2012         F  0.6835552982049797  0.31644470179502027
2013         M  0.6390352093152204   0.3609647906847796
2013         F  0.6763819095477387   0.3236180904522613
2014         M   0.635593220338983   0.3644067796610169
2014         F  0.6708701134930644   0.3291298865069357
2015         M  0.6260993274702535   0.3739006725297465
2015         F  0.6583230748187663  0.34167692518123377
```

percents

[15]:
```
# or, if you want the previous ratios in percents
pop.percent('nat')
```

[15]:
```
time  sex\nat                 BE                  FO
2005        M    72.9421768707483    27.0578231292517
2005        F   74.63570856685348  25.364291433146516
2006        M   71.11220472440945  28.887795275590552
2006        F   75.16113818581984   24.83886181418016
2007        M    70.3788748564868  29.621125143513204
2007        F   74.09326424870466  25.906735751295336
2008        M   71.03887618425351   28.96112381574649
2008        F   73.79503977538606  26.204960224613945
2009        M   68.85883084577114  31.141169154228855
2009        F   73.69385884509624   26.30614115490376
2010        M   68.72656367181641  31.273436328183593
2010        F   71.63454465205237  28.365455347947623
2011        M   67.09223927700474   32.90776072299526
2011        F   70.44528725944654  29.554712740553448
2012        M   64.55952553160712  35.440474468392885
2012        F   68.35552982049798  31.644470179502026
2013        M   63.90352093152204   36.09647906847796
2013        F   67.63819095477388   32.36180904522613
2014        M  63.559322033898304  36.440677966101696
2014        F   67.08701134930644   32.91298865069357
2015        M   62.60993274702535   37.39006725297465
2015        F   65.83230748187663  34.167692518123374
```

growth_rate

using the same principle than `diff`

[16]:
```
pop.growth_rate('time')
```

[16]:
```
time  sex\nat                    BE                      FO
2006        M  0.010725110748426206     0.10685103708359522
2006        F  0.025745548165629694  -0.0025252525252525255
```

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```
2007        M  -0.010149942329873126     0.02555366269165247
2007        F  -0.012967998326709893     0.04430379746835443
2008        M   0.013516662782568165   -0.018272425249169437
2008        F  0.0025429116338207248     0.01818181818181818
2009        M    0.01839503334099793     0.12972363226170333
2009        F   0.019657577679137603                   0.025
2010        M    0.03454504402799729    0.040938592111832255
2010        F   0.009328358208955223     0.11962833914053426
2011        M    0.02073330423395897     0.10023980815347722
2011        F   0.029985623331279524      0.0912863070539419
2012        M   -0.04575582638443447     0.06800348735832606
2012        F    -0.0584247258225324     0.03897338403041825
2013        M    0.03293748599596684     0.06285714285714286
2013        F  -0.002329521389241847     0.03110704483074108
2014        M   0.024945770065075923     0.04032258064516129
2014        F    0.01634472511144131     0.04214729370008873
2015        M    0.02455026455026455     0.06718346253229975
2015        F  0.0052213868003341685     0.06343124733929331
```

shift

The `shift` method drops first label of an axis and shifts all subsequent labels

[17]:
```
pop.shift('time')
```

[17]:
```
time  sex\nat    BE    FO
2006        M  4289  1591
2006        F  4661  1584
2007        M  4335  1761
2007        F  4781  1580
2008        M  4291  1806
2008        F  4719  1650
2009        M  4349  1773
2009        F  4731  1680
2010        M  4429  2003
2010        F  4824  1722
2011        M  4582  2085
2011        F  4869  1928
2012        M  4677  2294
2012        F  5015  2104
2013        M  4463  2450
2013        F  4722  2186
2014        M  4610  2604
2014        F  4711  2254
2015        M  4725  2709
2015        F  4788  2349
```

[18]:
```
# when shift is applied on an (increasing) time axis,
# it effectively brings "past" data into the future
pop.shift('time').ignore_labels('time') == pop[2005:2014].ignore_labels('time')
```

[18]:
```
time*  sex\nat    BE    FO
    0        M  True  True
    0        F  True  True
    1        M  True  True
    1        F  True  True
```

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```
     2         M  True  True
     2         F  True  True
     3         M  True  True
     3         F  True  True
     4         M  True  True
     4         F  True  True
     5         M  True  True
     5         F  True  True
     6         M  True  True
     6         F  True  True
     7         M  True  True
     7         F  True  True
     8         M  True  True
     8         F  True  True
     9         M  True  True
     9         F  True  True
```

[19]:

```
# this is mostly useful when you want to do operations between the past and now
# as an example, here is an alternative implementation of the .diff method seen above:
pop.i[1:] - pop.shift('time')
```

[19]:

```
time  sex\nat    BE   FO
2006        M    46  170
2006        F   120   -4
2007        M   -44   45
2007        F   -62   70
2008        M    58  -33
2008        F    12   30
2009        M    80  230
2009        F    93   42
2010        M   153   82
2010        F    45  206
2011        M    95  209
2011        F   146  176
2012        M  -214  156
2012        F  -293   82
2013        M   147  154
2013        F   -11   68
2014        M   115  105
2014        F    77   95
2015        M   116  182
2015        F    25  149
```

Misc other interesting functions

There are a lot more interesting functions available:

- round, floor, ceil, trunc,
- exp, log, log10,
- sqrt, absolute, nan_to_num, isnan, isinf, inverse,
- sin, cos, tan, arcsin, arccos, arctan
- and many many more…

4.2.9 Working With Sessions

Import the LArray library:

```
[2]: from larray import *
```

Check the version of LArray:

```
[3]: from larray import __version__
     __version__
```

```
[3]: '0.31-dev'
```

Before To Continue

If you not yet comfortable with creating, saving and loading sessions, please read first the *Creating Sessions* and *Loading and Dumping Sessions* sections of the tutorial before going further.

Exploring Content

To get the list of items names of a session, use the *names* shortcut (be careful that the list is sorted alphabetically and does not follow the internal order!):

```
[4]: # load a session representing the results of a demographic model
     filepath_hdf = get_example_filepath('population_session.h5')
     s_pop = Session(filepath_hdf)

     # print the content of the session
     print(s_pop.names)
```

```
['births', 'country', 'deaths', 'even_years', 'gender', 'odd_years', 'pop', 'time']
```

To get more information of items of a session, the *summary* will provide not only the names of items but also the list of labels in the case of axes or groups and the list of axes, the shape and the dtype in the case of arrays:

```
[5]: # print the content of the session
     print(s_pop.summary())
```

```
country: country ['Belgium' 'France' 'Germany'] (3)
gender: gender ['Male' 'Female'] (2)
time: time [2013 2014 2015] (3)
even_years: time['2014'] » even_years (1)
odd_years: time[2013 2015] » odd_years (2)
births: country, gender, time (3 x 2 x 3) [int32]
deaths: country, gender, time (3 x 2 x 3) [int32]
pop: country, gender, time (3 x 2 x 3) [int32]
```

Selecting And Filtering Items

To select an item, simply use the syntax <session_var>.<item_name>:

```
[6]: s_pop.pop
```

[6]:
```
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male  31772665  31936596  32175328
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female  41142770  41210540  41362080
```

To return a new session with selected items, use the syntax `<session_var>[list, of, item, names]`:

[7]:
```
s_pop_new = s_pop['pop', 'births', 'deaths']

s_pop_new.names
```

[7]:
```
['births', 'deaths', 'pop']
```

The *filter* method allows you to select all items of the same kind (i.e. all axes, or groups or arrays) or all items with names satisfying a given pattern:

[8]:
```
# select only arrays of a session
s_pop.filter(kind=LArray)
```

[8]:
```
Session(births, deaths, pop)
```

[9]:
```
# selection all items with a name starting with a letter between a and k
s_pop.filter(pattern='[a-k]*')
```

[9]:
```
Session(country, gender, even_years, births, deaths)
```

Arithmetic Operations On Sessions

Session objects accept binary operations with a scalar:

[10]:
```
# get population, births and deaths in millions
s_pop_div = s_pop / 1e6

s_pop_div.pop
```

[10]:
```
country  gender\time       2013       2014       2015
Belgium         Male   5.472856   5.493792   5.524068
Belgium       Female   5.665118   5.687048   5.713206
 France         Male  31.772665  31.936596  32.175328
 France       Female  33.827685  34.005671  34.280951
Germany         Male  39.380976  39.556923  39.835457
Germany       Female   41.14277   41.21054   41.36208
```

with an array (please read the documentation of the *random.choice* function first if you don't know it):

[11]:
```
from larray import random
random_multiplicator = random.choice([0.98, 1.0, 1.02], p=[0.15, 0.7, 0.15], axes=s_
↪pop.pop.axes)
random_multiplicator
```

[11]:
```
country  gender\time  2013  2014  2015
Belgium         Male   1.0  1.02   1.0
Belgium       Female  1.02   1.0   1.0
 France         Male  1.02   1.0  0.98
```

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```
 France        Female   1.0   1.0   1.0
Germany          Male   1.0   1.0  1.02
Germany        Female   1.0   1.0   1.0
```

[12]:
```
# multiply all variables of a session by a common array
s_pop_rand = s_pop * random_multiplicator

s_pop_rand.pop
```

```
---------------------------------------------------------------------------
AssertionError                            Traceback (most recent call last)
<ipython-input-12-5f82b3cbbdf9> in <module>
      1 # multiply all variables of a session by a common array
----> 2 s_pop_rand = s_pop * random_multiplicator
      3 
      4 s_pop_rand.pop

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/session.py in opmethod(self,␣
↪other)
    941                 res = []
    942                 for name in all_keys:
--> 943                     self_item = self.get(name, nan)
    944                     other_operand = other.get(name, nan) if hasattr(other,␣
↪'get') else other
    945                     if arrays_only and not isinstance(self_item, LArray):

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/session.py in get(self, key,␣
↪default)
    299         """
    300         try:
--> 301             return self[key]
    302         except KeyError:
    303             return default

~/checkouts/readthedocs.org/user_builds/larray-test/conda/documentation/lib/python3.6/
↪site-packages/larray-0.31.dev0-py3.6.egg/larray/core/session.py in __getitem__(self,
↪ key)
    255             return Session([(name, self[name]) for name in truenames])
    256         elif isinstance(key, (tuple, list)):
--> 257             assert all(isinstance(k, str) for k in key)
    258             return Session([(k, self[k]) for k in key])
    259         else:

AssertionError: 
```

with another session:

[13]:
```
# compute the difference between each array of the two sessions
s_diff = s_pop - s_pop_rand

s_diff.births
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-13-db5241167ae2> in <module>
```

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```
      1 # compute the difference between each array of the two sessions
----> 2 s_diff = s_pop - s_pop_rand
      3 
      4 s_diff.births

NameError: name 's_pop_rand' is not defined
```

Applying Functions On All Arrays

In addition to the classical arithmetic operations, the *apply* method can be used to apply the same function on all arrays. This function should take a single element argument and return a single value:

[14]:
```
# force conversion to type int
def as_type_int(array):
    return array.astype(int)

s_pop_rand_int = s_pop_rand.apply(as_type_int)

print('pop array before calling apply:')
print(s_pop_rand.pop)
print()
print('pop array after calling apply:')
print(s_pop_rand_int.pop)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-14-5ba7352689a5> in <module>
      3     return array.astype(int)
      4 
----> 5 s_pop_rand_int = s_pop_rand.apply(as_type_int)
      6 
      7 print('pop array before calling apply:')

NameError: name 's_pop_rand' is not defined
```

It is possible to pass a function with additional arguments:

[15]:
```
# passing the LArray.astype method directly with argument
# dtype defined as int
s_pop_rand_int = s_pop_rand.apply(LArray.astype, dtype=int)

print('pop array before calling apply:')
print(s_pop_rand.pop)
print()
print('pop array after calling apply:')
print(s_pop_rand_int.pop)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-15-526833a6ec98> in <module>
      1 # passing the LArray.astype method directly with argument
      2 # dtype defined as int
----> 3 s_pop_rand_int = s_pop_rand.apply(LArray.astype, dtype=int)
      4 
      5 print('pop array before calling apply:')
```

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```
NameError: name 's_pop_rand' is not defined
```

It is also possible to apply a function on non-LArray objects of a session. Please refer the documentation of the *apply* method.

Comparing Sessions

Being able to compare two sessions may be useful when you want to compare two different models expected to give the same results or when you have updated your model and want to see what are the consequences of the recent changes.

Session objects provide the two methods to compare two sessions: *equals* and *element_equals*.

The `equals` method will return True if **all items** from both sessions are identical, False otherwise:

```
[16]: # load a session representing the results of a demographic model
      filepath_hdf = get_example_filepath('population_session.h5')
      s_pop = Session(filepath_hdf)

      # create a copy of the original session
      s_pop_copy = Session(filepath_hdf)

      # 'equals' returns True if all items of the two sessions have exactly the same items
      s_pop.equals(s_pop_copy)
```

```
[16]: True
```

```
[17]: # create a copy of the original session but with the array
      # 'births' slightly modified for some labels combination
      s_pop_alternative = Session(filepath_hdf)
      s_pop_alternative.births *= random_multiplicator

      # 'equals' returns False if at least on item of the two sessions are different in␣
      ↪values or axes
      s_pop.equals(s_pop_alternative)
```

```
[17]: False
```

```
[18]: # add an array to the session
      s_pop_new_output = Session(filepath_hdf)
      s_pop_new_output.gender_ratio = s_pop_new_output.pop.ratio('gender')

      # 'equals' returns False if at least on item is not present in the two sessions
      s_pop.equals(s_pop_new_output)
```

```
[18]: False
```

The `element_equals` method will compare items of two sessions one by one and return an array of boolean values:

```
[19]: # 'element_equals' compare arrays one by one
      s_pop.element_equals(s_pop_copy)
```

```
[19]: name  country  gender  time  even_years  odd_years  births  deaths  pop
                True    True  True        True       True    True    True  True
```

```
[20]: # array 'births' is different between the two sessions
      s_pop.element_equals(s_pop_alternative)
```

```
[20]: name   country  gender  time  even_years  odd_years  births  deaths   pop
                True    True  True        True       True   False    True  True
```

The == operator return a new session with boolean arrays with elements compared element-wise:

```
[21]: s_same_values = s_pop == s_pop_alternative

      s_same_values.births
```

```
[21]: country  gender\time   2013   2014   2015
      Belgium         Male   True  False   True
      Belgium       Female  False   True   True
       France         Male  False   True  False
       France       Female   True   True   True
      Germany         Male   True   True  False
      Germany       Female   True   True   True
```

This also works for axes and groups:

```
[22]: s_same_values.country
```

```
[22]: country  Belgium  France  Germany
                  True    True     True
```

The != operator does the opposite of == operator:

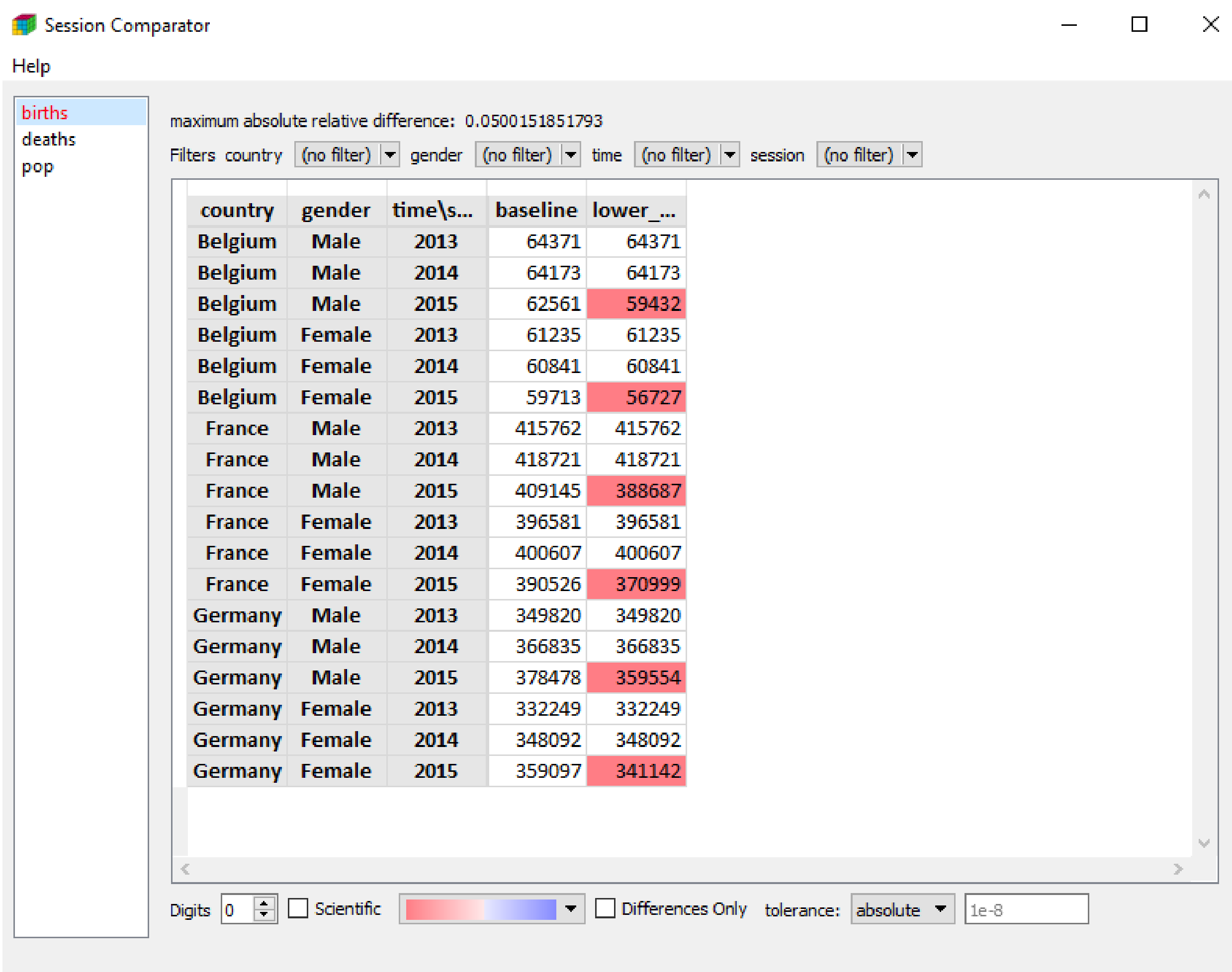
```
[23]: s_different_values = s_pop != s_pop_alternative

      s_different_values.births
```

```
[23]: country  gender\time   2013   2014   2015
      Belgium         Male  False   True  False
      Belgium       Female   True  False  False
       France         Male   True  False   True
       France       Female  False  False  False
      Germany         Male  False  False   True
      Germany       Female  False  False  False
```

A more visual way is to use the *compare* function which will open the `Editor`.

```
compare(s_pop, s_pop_alternative, names=['baseline', 'lower_birth_rate'])
```



country	gender	time\s...	baseline	lower_...
Belgium	Male	2013	64371	64371
Belgium	Male	2014	64173	64173
Belgium	Male	2015	62561	59432
Belgium	Female	2013	61235	61235
Belgium	Female	2014	60841	60841
Belgium	Female	2015	59713	56727
France	Male	2013	415762	415762
France	Male	2014	418721	418721
France	Male	2015	409145	388687
France	Female	2013	396581	396581
France	Female	2014	400607	400607
France	Female	2015	390526	370999
Germany	Male	2013	349820	349820
Germany	Male	2014	366835	366835
Germany	Male	2015	378478	359554
Germany	Female	2013	332249	332249
Germany	Female	2014	348092	348092
Germany	Female	2015	359097	341142

Session API

Please go to the *Session* section of the API Reference to get the list of all methods of Session objects.

4.2.10 Compatibility with pandas

To convert a LArray object into a pandas DataFrame, the method `to_frame()` can be used:

```
In [1]: df = pop.to_frame()

In [2]: df
Out[2]:
year        2015  2016  2017
age    sex
0-9    F     0.0   0.0   0.0
       M     0.0   0.0   0.0
10-17  F     0.0   0.0   0.0
       M     0.0   0.0   0.0
18-66  F     0.0   0.0   0.0
       M     0.0   0.0   0.0
```

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```
67+    F      0.0    0.0    0.0
       M      0.0    0.0    0.0
```

Inversely, to convert a DataFrame into a LArray object, use the function `aslarray()`:

```
In [3]: pop = aslarray(df)

In [4]: pop
Out[4]:
  age  sex\year  2015  2016  2017
  0-9         F   0.0   0.0   0.0
  0-9         M   0.0   0.0   0.0
10-17         F   0.0   0.0   0.0
10-17         M   0.0   0.0   0.0
18-66         F   0.0   0.0   0.0
18-66         M   0.0   0.0   0.0
  67+         F   0.0   0.0   0.0
  67+         M   0.0   0.0   0.0
```

4.3 API Reference

4.3.1 Axis

Axis(labels[, name])	Represents an axis.

larray.Axis

class larray.**Axis**(*labels*, *name=None*)

Represents an axis. It consists of a name and a list of labels.

Parameters

labels [array-like or int] collection of values usable as labels, i.e. numbers or strings or the size of the axis. In the last case, a wildcard axis is created.

name [str or Axis, optional] name of the axis or another instance of Axis. In the second case, the name of the other axis is simply copied. By default None.

Examples

```
>>> gender = Axis(['M', 'F'], 'gender')
>>> gender
Axis(['M', 'F'], 'gender')
>>> gender.name
'gender'
>>> list(gender.labels)
['M', 'F']
```

using a string definition

```
>>> gender = Axis('gender=M,F')
>>> gender
Axis(['M', 'F'], 'gender')
>>> age = Axis('age=0..9')
>>> age
Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9], 'age')
>>> code = Axis('code=A,C..E,F..G,Z')
>>> code
Axis(['A', 'C', 'D', 'E', 'F', 'G', 'Z'], 'code')
```

a wildcard axis only needs a length

```
>>> row = Axis(10, 'row')
>>> row
Axis(10, 'row')
>>> row.labels
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
```

axes can also be defined without name

```
>>> anonymous = Axis('0..4')
>>> anonymous
Axis([0, 1, 2, 3, 4], None)
```

Attributes

labels [array-like or int] labels of the axis.

name [str] name of the axis. None in the case of an anonymous axis.

__init__(*self*, *labels*, *name=None*)
Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self, labels[, name])	Initialize self.
align(self, other[, join])	Align axis with other object using specified join method.
all(self[, name])	(Deprecated) Returns a group containing all labels.
apply(self, func)	Returns a new axis with the labels transformed by func.
by(self, length[, step, template])	Split axis into several groups of specified length.
containing(self, substring)	Returns a group with all the labels containing the specified substring.
copy(self)	Returns a copy of the axis.
difference(self, other)	Returns axis with the (set) difference of this axis labels and other labels.
endingwith(self, suffix)	Returns a group with the labels ending with the specified string.
endswith(*args, **kwargs)	
equals(self, other)	Checks if self is equal to another axis.
extend(self, labels)	Append new labels to an axis or increase its length in case of wildcard axis.

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Table 2 – continued from previous page

group(self, *args, **kwargs)	
ignore_labels(self)	Returns a wildcard axis with the same name and length than this axis.
index(self, key)	Translates a label key to its numerical index counterpart.
insert(self, new_labels[, before, after])	Return a new axis with *new_labels* inserted before *before* or after *after*.
intersection(self, other)	Returns axis with the (set) intersection of this axis labels and other labels.
iscompatible(self, other)	Checks if self is compatible with another axis.
labels_summary(self)	Returns a short representation of the labels.
matches(*args, **kwargs)	
matching(self[, deprecated, pattern, regex])	Returns a group with all the labels matching the specified pattern or regular expression.
rename(self, name)	Renames the axis.
replace(self, old[, new])	Returns a new axis with some labels replaced.
split(self[, sep, names, regex, return_labels])	Split axis and returns a list of Axis.
startingwith(self, prefix)	Returns a group with the labels starting with the specified string.
startswith(*args, **kwargs)	
subaxis(self, key[, name])	Returns an axis for a sub-array.
to_hdf(self, filepath[, key])	Writes axis to a HDF file.
translate(*args, **kwargs)	
union(self, other)	Returns axis with the union of this axis labels and other labels.

Attributes

dtype	
i	Allows to define a subset using positions along the axis instead of labels.
id	
iswildcard	
labels	labels of the axis.
name	

Exploring

Axis.name	Name of the axis. None in the case of an anonymous axis.
Axis.labels	Labels of the axis.
Axis.labels_summary	Short representation of the labels.
Axis.dtype	Data type for the axis labels.

Copying

Axis.copy(self)	Returns a copy of the axis.

larray.Axis.copy

`Axis.copy(self)`

Returns a copy of the axis.

Searching

Axis.index(self, key)	Translates a label key to its numerical index counterpart.
Axis.containing(self, substring)	Returns a group with all the labels containing the specified substring.
Axis.startingwith(self, prefix)	Returns a group with the labels starting with the specified string.
Axis.endingwith(self, suffix)	Returns a group with the labels ending with the specified string.
Axis.matching(self[, deprecated, pattern, regex])	Returns a group with all the labels matching the specified pattern or regular expression.

larray.Axis.index

`Axis.index(self, key)`

Translates a label key to its numerical index counterpart.

Parameters

key [key] Everything usable as a key.

Returns

(array of) int Numerical index(ices) of (all) label(s) represented by the key

Notes

Fancy index with boolean vectors are passed through unmodified

Examples

```
>>> people = Axis(['John Doe', 'Bruce Wayne', 'Bruce Willis', 'Waldo', 'Arthur␣
↪Dent', 'Harvey Dent'], 'people')
>>> people.index('Waldo')
3
>>> people.index(people.containing('Bruce'))
array([1, 2])
```

larray.Axis.containing

`Axis.containing(self, substring)`

Returns a group with all the labels containing the specified substring.

Parameters

substring [str or Group] The substring to search for.

Returns

LGroup Group containing all the labels containing the substring.

Examples

```
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
>>> people.containing('Will')
people['Bruce Willis']
```

larray.Axis.startingwith

Axis.**startingwith**(*self*, *prefix*)

Returns a group with the labels starting with the specified string.

Parameters

prefix [str or Group] The prefix to search for.

Returns

LGroup Group containing all the labels starting with the given string.

Examples

```
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Waldo', 'Arthur Dent', 'Harvey␣
↪Dent'], 'people')
>>> people.startingwith('Bru')
people['Bruce Wayne', 'Bruce Willis']
```

larray.Axis.endingwith

Axis.**endingwith**(*self*, *suffix*)

Returns a group with the labels ending with the specified string.

Parameters

suffix [str or Group] The suffix to search for.

Returns

LGroup Group containing all the labels ending with the given string.

Examples

```
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Waldo', 'Arthur Dent', 'Harvey␣
↪Dent'], 'people')
>>> people.endingwith('Dent')
people['Arthur Dent', 'Harvey Dent']
```

larray.Axis.matching

Axis.**matching**(*self*, *deprecated=None*, *pattern=None*, *regex=None*)
Returns a group with all the labels matching the specified pattern or regular expression.

Parameters

pattern [str or Group] Pattern to match. * *?* matches any single character * * matches any number of characters * [seq] matches any character in seq * [!seq] matches any character not in seq

To match any of the special characters above, wrap the character in brackets. For example, *[?]* matches the character *?*.

regex [str or Group] Regular expression pattern to match. Regular expressions are more powerful than what the simple patterns supported by the *pattern* argument but are also more complex to write. See Regular Expression for more details about how to build a regular expression pattern.

Returns

LGroup Group containing all the labels matching the pattern.

Examples

```
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Waldo', 'Arthur Dent', 'Harvey␣
↪Dent'], 'people')
```

```
>>> # All labels starting with "A" and ending with "t"
>>> people.matching(pattern='A*t')
people['Arthur Dent']
>>> # All labels containing "W" and ending with "s"
>>> people.matching(pattern='*W*s')
people['Bruce Willis']
>>> # All labels with exactly 5 characters
>>> people.matching(pattern='?????')
people['Waldo']
>>> # All labels starting with either "A" or "B"
>>> people.matching(pattern='[AB]*')
people['Bruce Wayne', 'Bruce Willis', 'Arthur Dent']
```

Regular expressions are more powerful but usually harder to write and less readable

```
>>> # All labels starting with "W" and ending with "o"
>>> people.matching(regex='A.*t')
people['Arthur Dent']
>>> # All labels not containing character "a"
>>> people.matching(regex='^[^a]*$')
people['Bruce Willis', 'Arthur Dent']
```

Modifying/Selecting

Axis.__getitem__(self, key)	Returns a group (list or unique element) of label(s) usable in .sum or .filter

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Table 6 – continued from previous page

Axis.i	Allows to define a subset using positions along the axis instead of labels.
Axis.by(self, length[, step, template])	Split axis into several groups of specified length.
Axis.rename(self, name)	Renames the axis.
Axis.subaxis(self, key[, name])	Returns an axis for a sub-array.
Axis.extend(self, labels)	Append new labels to an axis or increase its length in case of wildcard axis.
Axis.insert(self, new_labels[, before, after])	Return a new axis with *new_labels* inserted before *before* or after *after*.
Axis.replace(self, old[, new])	Returns a new axis with some labels replaced.
Axis.apply(self, func)	Returns a new axis with the labels transformed by func.
Axis.union(self, other)	Returns axis with the union of this axis labels and other labels.
Axis.intersection(self, other)	Returns axis with the (set) intersection of this axis labels and other labels.
Axis.difference(self, other)	Returns axis with the (set) difference of this axis labels and other labels.
Axis.align(self, other[, join])	Align axis with other object using specified join method.
Axis.split(self[, sep, names, regex, . . .])	Split axis and returns a list of Axis.
Axis.ignore_labels(self)	Returns a wildcard axis with the same name and length than this axis.

larray.Axis.__getitem__

Axis.**__getitem__**(*self*, *key*)

Returns a group (list or unique element) of label(s) usable in .sum or .filter

key is a label-based key (other axis, slice and fancy indexing are supported)

Returns

Group group containing selected label(s)/position(s).

Notes

key is label-based (slice and fancy indexing are supported)

larray.Axis.i

Axis.**i**

Allows to define a subset using positions along the axis instead of labels.

Examples

```
>>> from larray import ndtest
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> arr = ndtest([sex, time])
>>> arr
sex\\time  2007  2008  2009  2010
       M     0     1     2     3
```

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```
        F      4      5      6      7
>>> arr[time.i[0, -1]]
sex\\time  2007  2010
        M      0      3
        F      4      7
```

larray.Axis.by

Axis.**by**(*self*, *length*, *step=None*, *template=None*)

Split axis into several groups of specified length.

Parameters

length [int] length of groups

step [int, optional] step between groups. Defaults to length.

template [str, optional] template describing how group names are generated. It is a string containing specific arguments written inside brackets {}. Available arguments are {start} and {end} representing the first and last label of each group. By default, template is defined as '{start}:{end}'.

Returns

list of Group

Notes

step can be smaller than length, in which case, this will produce overlapping groups.

Examples

```
>>> age = Axis('age=0..6')
>>> age
Axis([0, 1, 2, 3, 4, 5, 6], 'age')
>>> age.by(3)
(age.i[0:3] >> '0:2', age.i[3:6] >> '3:5', age.i[6:7] >> '6')
>>> age.by(3, step=2)
(age.i[0:3] >> '0:2', age.i[2:5] >> '2:4', age.i[4:7] >> '4:6', age.i[6:7] >> '6')
>>> age.by(3, template='{start}-{end}')
(age.i[0:3] >> '0-2', age.i[3:6] >> '3-5', age.i[6:7] >> '6')
```

larray.Axis.rename

Axis.**rename**(*self*, *name*)

Renames the axis.

Parameters

name [str] the new name for the axis.

Returns

Axis a new Axis with the same labels but a different name.

Examples

```
>>> sex = Axis('sex=M,F')
>>> sex
Axis(['M', 'F'], 'sex')
>>> sex.rename('gender')
Axis(['M', 'F'], 'gender')
```

larray.Axis.subaxis

`Axis.subaxis`(*self*, *key*, *name=None*)

Returns an axis for a sub-array.

Parameters

key [int, or collection (list, slice, array, LArray) of them] Indices of labels to use for the new axis.

name [str, optional] Name of the subaxis. Defaults to the name of the parent axis.

Returns

Axis Subaxis. If key is a None slice and name is None, the original Axis is returned. If key is a LArray, the list of axes is returned.

Examples

```
>>> age = Axis(range(100), 'age')
>>> age.subaxis(range(10, 19), 'teenagers')
Axis([10, 11, 12, 13, 14, 15, 16, 17, 18], 'teenagers')
```

larray.Axis.extend

`Axis.extend`(*self*, *labels*)

Append new labels to an axis or increase its length in case of wildcard axis. Note that *extend* does not occur in-place: a new axis object is allocated, filled and returned.

Parameters

labels [int, iterable or Axis] New labels to append to the axis. Passing directly another Axis is also possible. If the current axis is a wildcard axis, passing a length is enough.

Returns

Axis A copy of the axis with new labels appended to it or with increased length (if wildcard).

Examples

```
>>> time = Axis([2007, 2008], 'time')
>>> time
Axis([2007, 2008], 'time')
>>> time.extend([2009, 2010])
Axis([2007, 2008, 2009, 2010], 'time')
```

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```
>>> waxis = Axis(10, 'wildcard_axis')
>>> waxis
Axis(10, 'wildcard_axis')
>>> waxis.extend(5)
Axis(15, 'wildcard_axis')
>>> waxis.extend([11, 12, 13, 14])
Traceback (most recent call last):
...
ValueError: Axis to append must (not) be wildcard if self is (not) wildcard
```

larray.Axis.insert

Axis.**insert**(*self*, *new_labels*, *before=None*, *after=None*)

Return a new axis with *new_labels* inserted before *before* or after *after*.

Parameters

new_labels [scalar, tuple/list/array of scalars, Group or Axis] New label(s) to append to the axis.

before [scalar or Group, optional] Label or group before which to insert *new_labels*.

after [scalar or Group, optional] Label or group after which to insert *new_labels*.

Returns

Axis A copy of the axis with the new labels inserted.

Examples

```
>>> time = Axis([2007, 2009], 'time')
>>> time.insert(2008, before=2009)
Axis([2007, 2008, 2009], 'time')
>>> time.insert(2008, after=2007)
Axis([2007, 2008, 2009], 'time')
>>> time.insert(2008, before=time.i[1])
Axis([2007, 2008, 2009], 'time')
>>> time.insert(2008, after=time.i[0])
Axis([2007, 2008, 2009], 'time')
>>> b = Axis(['b1', 'b2'], 'b')
>>> b.insert('b1.5', before='b2')
Axis(['b1', 'b1.5', 'b2'], 'b')
>>> b.insert(['b1.1', 'b1.2'], before='b2')
Axis(['b1', 'b1.1', 'b1.2', 'b2'], 'b')
>>> c = Axis(['c1', 'c2'], 'c')
>>> b.insert(c, before='b2')
Axis(['b1', 'c1', 'c2', 'b2'], 'b')
```

larray.Axis.replace

Axis.**replace**(*self*, *old*, *new=None*)

Returns a new axis with some labels replaced.

Parameters

old [any scalar (bool, int, str, . . .), tuple/list/array of scalars, or a mapping.] the label(s) to be replaced. Old can be a mapping {old1: new1, old2: new2, . . . }

new [any scalar (bool, int, str, . . .) or tuple/list/array of scalars, optional] the new label(s). This is argument must not be used if old is a mapping.

Returns

Axis a new Axis with the old labels replaced by new labels.

Examples

```
>>> sex = Axis('sex=M,F')
>>> sex
Axis(['M', 'F'], 'sex')
>>> sex.replace('M', 'Male')
Axis(['Male', 'F'], 'sex')
>>> sex.replace({'M': 'Male', 'F': 'Female'})
Axis(['Male', 'Female'], 'sex')
>>> sex.replace(['M', 'F'], ['Male', 'Female'])
Axis(['Male', 'Female'], 'sex')
```

larray.Axis.apply

`Axis.apply(self, func)`

Returns a new axis with the labels transformed by func.

Parameters

func [callable] A callable which takes a single argument and returns a single value.

Returns

Axis a new Axis with the transformed labels.

Examples

```
>>> sex = Axis('sex=MALE,FEMALE')
>>> sex.apply(str.capitalize)
Axis(['Male', 'Female'], 'sex')
```

larray.Axis.union

`Axis.union(self, other)`

Returns axis with the union of this axis labels and other labels.

Labels relative order will be kept intact, but only unique labels will be returned. Labels from this axis will be before labels from other.

Parameters

other [Axis or any sequence of labels] other labels

Returns

Axis

Examples

```
>>> a = Axis('a=a0..a2')
>>> a.union('a1')
Axis(['a0', 'a1', 'a2'], 'a')
>>> a.union('a3')
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
>>> a.union(Axis('a=a1..a3'))
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
>>> a.union('a1..a3')
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
>>> a.union(['a1', 'a2', 'a3'])
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
```

larray.Axis.intersection

`Axis.`**`intersection`**(*self*, *other*)

Returns axis with the (set) intersection of this axis labels and other labels.

In other words, this will use labels from this axis if they are also in other. Labels relative order will be kept intact.

Parameters

other [Axis or any sequence of labels] other labels

Returns

Axis

Examples

```
>>> a = Axis('a=a0..a2')
>>> a.intersection('a1')
Axis(['a1'], 'a')
>>> a.intersection('a3')
Axis([], 'a')
>>> a.intersection(Axis('a=a1..a3'))
Axis(['a1', 'a2'], 'a')
>>> a.intersection('a1..a3')
Axis(['a1', 'a2'], 'a')
>>> a.intersection(['a1', 'a2', 'a3'])
Axis(['a1', 'a2'], 'a')
```

larray.Axis.difference

`Axis.`**`difference`**(*self*, *other*)

Returns axis with the (set) difference of this axis labels and other labels.

In other words, this will use labels from this axis if they are not in other. Labels relative order will be kept intact.

Parameters

other [Axis or any sequence of labels] other labels

Returns

Axis

Examples

```
>>> a = Axis('a=a0..a2')
>>> a.difference('a1')
Axis(['a0', 'a2'], 'a')
>>> a.difference('a3')
Axis(['a0', 'a1', 'a2'], 'a')
>>> a.difference(Axis('a=a1..a3'))
Axis(['a0'], 'a')
>>> a.difference('a1..a3')
Axis(['a0'], 'a')
>>> a.difference(['a1', 'a2', 'a3'])
Axis(['a0'], 'a')
```

larray.Axis.align

`Axis.align` (*self*, *other*, *join='outer'*)

Align axis with other object using specified join method.

Parameters

other [Axis or label sequence]

join [{'outer', 'inner', 'left', 'right', 'exact'}, optional] Defaults to 'outer'.

Returns

Axis Aligned axis

See also:

LArray.align

Examples

```
>>> axis1 = Axis('a=a0..a2')
>>> axis2 = Axis('a=a1..a3')
>>> axis1.align(axis2)
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
>>> axis1.align(axis2, join='inner')
Axis(['a1', 'a2'], 'a')
>>> axis1.align(axis2, join='left')
Axis(['a0', 'a1', 'a2'], 'a')
>>> axis1.align(axis2, join='right')
Axis(['a1', 'a2', 'a3'], 'a')
>>> axis1.align(axis2, join='exact')   # doctest: +NORMALIZE_WHITESPACE
Traceback (most recent call last):
...
ValueError: align method with join='exact' expected
Axis(['a0', 'a1', 'a2'], 'a') to be equal to Axis(['a1', 'a2', 'a3'], 'a')
```

larray.Axis.split

`Axis.split(self, sep='_', names=None, regex=None, return_labels=False)`

Split axis and returns a list of Axis.

Parameters

sep [str, optional] Delimiter to use for splitting. Defaults to '_'. When *regex* is provided, the delimiter is only used on *names* if given as one string or on axis name if *names* is None.

names [str or list of str, optional] Names of resulting axes. Defaults to None.

regex [str, optional] Use regex instead of delimiter to split labels. Defaults to None.

labels [bool, optional] Whether or not split labels must be returned (as a tuple of tuples). These labels are suitable for indexing via array.points[labels]. Defaults to False.

Returns

list of Axis or (list of Axis, array-like)

Examples

```
>>> a_b = Axis('a_b=a0_b0,a0_b1,a0_b2,a1_b0,a1_b1,a1_b2')
>>> a_b.split()
[Axis(['a0', 'a1'], 'a'), Axis(['b0', 'b1', 'b2'], 'b')]
```

larray.Axis.ignore_labels

`Axis.ignore_labels(self)`

Returns a wildcard axis with the same name and length than this axis.

Useful when you want to apply operations between two arrays with the same shape but incompatible axes (different labels).

Returns

Axis

Examples

```
>>> a = Axis('a=a1,a2')
>>> a
Axis(['a1', 'a2'], 'a')
>>> a.ignore_labels()
Axis(2, 'a')
```

Testing

`Axis.iscompatible`(self, other)	Checks if self is compatible with another axis.
`Axis.equals`(self, other)	Checks if self is equal to another axis.

larray.Axis.iscompatible

Axis.**iscompatible**(*self*, *other*)

Checks if self is compatible with another axis.

- Two non-wildcard axes are compatible if they have the same name and labels.
- A wildcard axis of length 1 is compatible with any other axis sharing the same name.
- A wildcard axis of length > 1 is compatible with any axis of the same length or length 1 and sharing the same name.

Parameters

other [Axis] Axis to compare with.

Returns

bool True if input axis is compatible with self, False otherwise.

Examples

```
>>> a10  = Axis(range(10), 'a')
>>> wa10 = Axis(10, 'a')
>>> wa1  = Axis(1, 'a')
>>> b10  = Axis(range(10), 'b')
>>> a10.iscompatible(b10)
False
>>> a10.iscompatible(wa10)
True
>>> a10.iscompatible(wa1)
True
>>> wa1.iscompatible(b10)
False
```

larray.Axis.equals

Axis.**equals**(*self*, *other*)

Checks if self is equal to another axis. Two axes are equal if they have the same name and label(s).

Parameters

other [Axis] Axis to compare with.

Returns

bool True if input axis is equal to self, False otherwise.

Examples

```
>>> age = Axis(range(5), 'age')
>>> age_2 = Axis(5, 'age')
>>> age_3 = Axis(range(5), 'young children')
>>> age_4 = Axis([0, 1, 2, 3, 4], 'age')
>>> age.equals(age_2)
False
```

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```
>>> age.equals(age_3)
False
>>> age.equals(age_4)
True
```

Save

Axis.to_hdf(self, filepath[, key])	Writes axis to a HDF file.

larray.Axis.to_hdf

Axis.**to_hdf**(*self*, *filepath*, *key=None*)

Writes axis to a HDF file.

A HDF file can contain multiple axes. The 'key' parameter is a unique identifier for the axis.

Parameters

filepath [str] Path where the hdf file has to be written.

key [str or Group, optional] Key (path) of the axis within the HDF file (see Notes below). If None, the name of the axis is used. Defaults to None.

Notes

Objects stored in a HDF file can be grouped together in *HDF groups*. If an object 'my_obj' is stored in a HDF group 'my_group', the key associated with this object is then 'my_group/my_obj'. Be aware that a HDF group can have subgroups.

Examples

```
>>> a = Axis("a=a0..a2")
```

Save axis

```
>>> # by default, the key is the name of the axis
>>> a.to_hdf('test.h5')             # doctest: +SKIP
```

Save axis with a specific key

```
>>> a.to_hdf('test.h5', 'a')        # doctest: +SKIP
```

Save axis in a specific HDF group

```
>>> a.to_hdf('test.h5', 'axes/a')   # doctest: +SKIP
```

4.3.2 Group

IGroup

IGroup(key[, name, axis])	Index Group.

larray.IGroup

class larray.**IGroup**(*key*, *name=None*, *axis=None*)

Index Group.

Represents a subset of indices of an axis.

Parameters

key [key] Anything usable for indexing. A key should be either a single position, a sequence of positions, or a slice with integer bounds.

name [str, optional] Name of the group.

axis [int, str, Axis, optional] Axis for group.

__init__(*self*, *key*, *name=None*, *axis=None*)

Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self, key[, name, axis])	Initialize self.
by(self, length[, step, template])	Split group into several groups of specified length.
containing(self, substring)	Returns a group with all the labels containing the specified substring.
difference(self, other)	Returns (set) difference of this label group and other.
endingwith(self, suffix)	Returns a group with the labels ending with the specified string.
equals(self, other)	Checks if this group is equal to another group.
eval(self)	Translate key to labels, if it is not already, expanding slices in the process.
intersection(self, other)	Returns (set) intersection of this label group and other.
matching(self[, deprecated, pattern, regex])	Returns a group with all the labels matching the specified pattern or regular expression.
named(self, name)	Returns group with a different name.
retarget_to(self, target_axis)	Retarget group to another axis.
set(self)	Creates LSet from this group
startingwith(self, prefix)	Returns a group with the labels starting with the specified string.
to_hdf(self, filepath[, key, axis_key])	Writes group to a HDF file.
to_label(self)	Translate key to labels, if it is not already
translate(self[, bound, stop])	compute position(s) of group
union(self, other)	Returns (set) union of this label group and other.
with_axis(self, axis)	Returns group with a different axis.

Attributes

axis

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format_string
key
name

IGroup.named(self, name)	Returns group with a different name.
IGroup.with_axis(self, axis)	Returns group with a different axis.
IGroup.by(self, length[, step, template])	Split group into several groups of specified length.
IGroup.equals(self, other)	Checks if this group is equal to another group.
IGroup.translate(self[, bound, stop])	compute position(s) of group
IGroup.union(self, other)	Returns (set) union of this label group and other.
IGroup.intersection(self, other)	Returns (set) intersection of this label group and other.
IGroup.difference(self, other)	Returns (set) difference of this label group and other.
IGroup.containing(self, substring)	Returns a group with all the labels containing the specified substring.
IGroup.startingwith(self, prefix)	Returns a group with the labels starting with the specified string.
IGroup.endingwith(self, suffix)	Returns a group with the labels ending with the specified string.
IGroup.matching(self[, deprecated, pattern, . . .])	Returns a group with all the labels matching the specified pattern or regular expression.
IGroup.to_hdf(self, filepath[, key, axis_key])	Writes group to a HDF file.

larray.IGroup.named

IGroup.**named**(*self*, *name*)

Returns group with a different name.

Parameters

name [str] new name for group

Returns

Group

larray.IGroup.with_axis

IGroup.**with_axis**(*self*, *axis*)

Returns group with a different axis.

Parameters

axis [int, str, Axis] new axis for group

Returns

Group

larray.IGroup.by

IGroup.**by**(*self*, *length*, *step=None*, *template=None*)

Split group into several groups of specified length.

Parameters

length [int] length of new groups

step [int, optional] step between groups. Defaults to length.

template [str, optional] template describing how group names are generated. It is a string containing specific arguments written inside brackets {}. Available arguments are {start} and {end} representing the first and last label of each group. By default, template is defined as '{start}:{end}'.

Returns

list of Group

Notes

step can be smaller than length, in which case, this will produce overlapping groups.

Examples

```
>>> from larray import Axis, X
>>> age = Axis('age=0..100')
>>> young_children = age[0:6]
>>> young_children.by(3)
(age.i[0:3] >> '0:2', age.i[3:6] >> '3:5', age.i[6:7] >> '6')
>>> young_children.by(3, step=2)
(age.i[0:3] >> '0:2', age.i[2:5] >> '2:4', age.i[4:7] >> '4:6', age.i[6:7] >> '6')
>>> young_children.by(3, template='{start}-{end}')
(age.i[0:3] >> '0-2', age.i[3:6] >> '3-5', age.i[6:7] >> '6')
```

larray.IGroup.equals

IGroup.**equals**(*self*, *other*)

Checks if this group is equal to another group. Two groups are equal if they have the same group and axis names and correspond to the same labels.

Parameters

other [Group] Group to compare with.

Returns

bool True if the other group is equal to this group, False otherwise.

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a3')
>>> a02 = a['a0:a2'] >> 'group_a'
```

Same group names, axis names and labels

```
>>> a02.equals(a02)
True
```

Different group names (one is None)

```
>>> a02.equals(a['a0:a2'])
False
```

Different axis name

```
>>> other_axis = a.rename('other_name')
>>> a02.equals(other_axis['a0:a2'] >> 'group_a')
False
```

Different labels

```
>>> a02.equals(a['a1:a3'] >> 'group_a')
False
```

Mixing slice and list groups

```
>>> a['a0:a2'].equals(a['a0,a1,a2'])
True
```

Mixing LGroup and IGroup

```
>>> a['a0:a2'].equals(a.i[0:3])
True
```

larray.IGroup.translate

`IGroup.`**`translate`**(*self*, *bound=None*, *stop=False*)
compute position(s) of group

larray.IGroup.union

`IGroup.`**`union`**(*self*, *other*)
Returns (set) union of this label group and other.

Labels relative order will be kept intact, but only unique labels will be returned. Labels from this group will be before labels from other.

Parameters

other [Group or any sequence of labels] other labels

Returns

LSet

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a2')
>>> a['a0', 'a1'].union(a['a1', 'a2'])
a['a0', 'a1', 'a2'].set()
>>> a['a0', 'a1'].union('a1,a2')
a['a0', 'a1', 'a2'].set()
```

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```
>>> a['a0', 'a1'].union(['a1', 'a2'])
a['a0', 'a1', 'a2'].set()
```

larray.IGroup.intersection

IGroup.**intersection**(*self*, *other*)

Returns (set) intersection of this label group and other.

In other words, this will return labels from this group which are also in other. Labels relative order will be kept intact, but only unique labels will be returned.

Parameters

other [Group or any sequence of labels] other labels

Returns

LSet

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a2')
>>> a['a0', 'a1'].intersection(a['a1', 'a2'])
a['a1'].set()
>>> a['a0', 'a1'].intersection('a1,a2')
a['a1'].set()
>>> a['a0', 'a1'].intersection(['a1', 'a2'])
a['a1'].set()
```

larray.IGroup.difference

IGroup.**difference**(*self*, *other*)

Returns (set) difference of this label group and other.

In other words, this will return labels from this group without those in other. Labels relative order will be kept intact, but only unique labels will be returned.

Parameters

other [Group or any sequence of labels] other labels

Returns

LSet

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a2')
>>> a['a0', 'a1'].difference(a['a1', 'a2'])
a['a0'].set()
>>> a['a0', 'a1'].difference('a1,a2')
```

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```
a['a0'].set()
>>> a['a0', 'a1'].difference(['a1', 'a2'])
a['a0'].set()
```

larray.IGroup.containing

IGroup.**containing**(*self*, *substring*)

Returns a group with all the labels containing the specified substring.

Parameters

substring [str or Group] The substring to search for.

Returns

LGroup Group containing all the labels containing the substring.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
>>> group = people.startingwith('Bru')
>>> group
people['Bruce Wayne', 'Bruce Willis']
>>> group.containing('Will')
people['Bruce Willis']
```

larray.IGroup.startingwith

IGroup.**startingwith**(*self*, *prefix*)

Returns a group with the labels starting with the specified string.

Parameters

prefix [str or Group] The prefix to search for.

Returns

LGroup Group containing all the labels starting with the given string.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Arthur Dent', 'Harvey Dent'], 'people')
>>> group = people.endingwith('Dent')
>>> group
people['Arthur Dent', 'Harvey Dent']
>>> group.startingwith('Art')
people['Arthur Dent']
```

larray.IGroup.endingwith

IGroup.**endingwith**(*self*, *suffix*)

Returns a group with the labels ending with the specified string.

Parameters

suffix [str or Group] The suffix to search for.

Returns

LGroup Group containing all the labels ending with the given string.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
>>> group = people.startingwith('Bru')
>>> group
people['Bruce Wayne', 'Bruce Willis']
>>> people.endingwith('yne')
people['Bruce Wayne']
```

larray.IGroup.matching

IGroup.**matching**(*self*, *deprecated=None*, *pattern=None*, *regex=None*)

Returns a group with all the labels matching the specified pattern or regular expression.

Parameters

pattern [str or Group] Pattern to match.

- *?* matches any single character
- * matches any number of characters
- [seq] matches any character in seq
- [!seq] matches any character not in seq

To match any of the special characters above, wrap the character in brackets. For example, *[?]* matches the character *?*.

regex [str or Group] Regular expression pattern to match. Regular expressions are more powerful than what the simple patterns supported by the *pattern* argument but are also more complex to write. See Regular Expression for more details about how to build a regular expression pattern.

Returns

LGroup Group containing all the labels matching the pattern.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
```

Let us create a group with all names starting with B

```
>>> group = people.startingwith('B')
>>> group
people['Bruce Wayne', 'Bruce Willis']
```

Within that group, all labels containing any characters then W then any characters then s are given by

```
>>> group.matching(pattern='*W*s')
people['Bruce Willis']
```

Regular expressions are more powerful but usually harder to write and less readable. For example, here are the labels not containing the letter "i".

```
>>> group.matching(regex='^[^i]*$')
people['Bruce Wayne']
```

larray.IGroup.to_hdf

`IGroup.to_hdf`(*self*, *filepath*, *key=None*, *axis_key=None*)

Writes group to a HDF file.

A HDF file can contain multiple groups. The 'key' parameter is a unique identifier for the group. The 'axis_key' parameter is the unique identifier for the associated axis. The associated axis will be saved if not already present in the HDF file.

Parameters

filepath [str] Path where the hdf file has to be written.

key [str or Group, optional] Key (path) of the group within the HDF file (see Notes below). If None, the name of the group is used. Defaults to None.

axis_key [str, optional] Key (path) of the associated axis in the HDF file (see Notes below). If None, the name of the axis associated with the group is used. Defaults to None.

Notes

Objects stored in a HDF file can be grouped together in *HDF groups*. If an object 'my_obj' is stored in a HDF group 'my_group', the key associated with this object is then 'my_group/my_obj'. Be aware that a HDF group can have subgroups.

Examples

```
>>> from larray import Axis
>>> a = Axis("a=a0..a2")
>>> a.to_hdf('test.h5')
>>> a01 = a['a0,a1'] >> 'a01'
```

Save group

```
>>> # by default, the key is the name of the group
>>> # and axis_key the name of the associated axis
>>> a01.to_hdf('test.h5')                    # doctest: +SKIP
```

Save group with a specific key

```
>>> a01.to_hdf('test.h5', 'a_01')            # doctest: +SKIP
```

Save group in a specific HDF group

```
>>> a.to_hdf('test.h5', 'groups/a01')        # doctest: +SKIP
```

The associated axis is saved with the group if not already present in the HDF file

```
>>> b = Axis("b=b0..b2")
>>> b01 = b['b0,b1'] >> 'b01'
>>> # save both the group 'b01' and the associated axis 'b'
>>> b01.to_hdf('test.h5')                    # doctest: +SKIP
```

LGroup

LGroup(key[, name, axis])	Label group.

larray.LGroup

class larray.**LGroup**(*key*, *name=None*, *axis=None*)

Label group.

Represents a subset of labels of an axis.

Parameters

key [key] Anything usable for indexing. A key should be either sequence of labels, a slice with label bounds or a string.

name [str, optional] Name of the group.

axis [int, str, Axis, optional] Axis for group.

Examples

```
>>> from larray import Axis, X
>>> age = Axis('0..100', 'age')
>>> teens = X.age[10:19].named('teens')
>>> teens
X.age[10:19] >> 'teens'
>>> teens = X.age[10:19] >> 'teens'
>>> teens
X.age[10:19] >> 'teens'
```

__init__(*self*, *key*, *name=None*, *axis=None*)

Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self, key[, name, axis])	Initialize self.
by(self, length[, step, template])	Split group into several groups of specified length.

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Table 14 – continued from previous page

containing(self, substring)	Returns a group with all the labels containing the specified substring.
difference(self, other)	Returns (set) difference of this label group and other.
endingwith(self, suffix)	Returns a group with the labels ending with the specified string.
equals(self, other)	Checks if this group is equal to another group.
eval(self)	Translate key to labels, if it is not already, expanding slices in the process.
intersection(self, other)	Returns (set) intersection of this label group and other.
matching(self[, deprecated, pattern, regex])	Returns a group with all the labels matching the specified pattern or regular expression.
named(self, name)	Returns group with a different name.
retarget_to(self, target_axis)	Retarget group to another axis.
set(self)	Creates LSet from this group
startingwith(self, prefix)	Returns a group with the labels starting with the specified string.
to_hdf(self, filepath[, key, axis_key])	Writes group to a HDF file.
to_label(self)	Translate key to labels, if it is not already
translate(self[, bound, stop])	compute position(s) of group
union(self, other)	Returns (set) union of this label group and other.
with_axis(self, axis)	Returns group with a different axis.

Attributes

axis
format_string
key
name

LGroup.named(self, name)	Returns group with a different name.
LGroup.with_axis(self, axis)	Returns group with a different axis.
LGroup.by(self, length[, step, template])	Split group into several groups of specified length.
LGroup.equals(self, other)	Checks if this group is equal to another group.
LGroup.translate(self[, bound, stop])	compute position(s) of group
LGroup.union(self, other)	Returns (set) union of this label group and other.
LGroup.intersection(self, other)	Returns (set) intersection of this label group and other.
LGroup.difference(self, other)	Returns (set) difference of this label group and other.
LGroup.containing(self, substring)	Returns a group with all the labels containing the specified substring.
LGroup.startingwith(self, prefix)	Returns a group with the labels starting with the specified string.
LGroup.endingwith(self, suffix)	Returns a group with the labels ending with the specified string.
LGroup.matching(self[, deprecated, pattern, ...])	Returns a group with all the labels matching the specified pattern or regular expression.
LGroup.to_hdf(self, filepath[, key, axis_key])	Writes group to a HDF file.

larray.LGroup.named

LGroup.**named**(*self*, *name*)

Returns group with a different name.

Parameters

name [str] new name for group

Returns

Group

larray.LGroup.with_axis

LGroup.**with_axis**(*self*, *axis*)

Returns group with a different axis.

Parameters

axis [int, str, Axis] new axis for group

Returns

Group

larray.LGroup.by

LGroup.**by**(*self*, *length*, *step=None*, *template=None*)

Split group into several groups of specified length.

Parameters

length [int] length of new groups

step [int, optional] step between groups. Defaults to length.

template [str, optional] template describing how group names are generated. It is a string containing specific arguments written inside brackets {}. Available arguments are {start} and {end} representing the first and last label of each group. By default, template is defined as '{start}:{end}'.

Returns

list of Group

Notes

step can be smaller than length, in which case, this will produce overlapping groups.

Examples

```
>>> from larray import Axis, X
>>> age = Axis('age=0..100')
>>> young_children = age[0:6]
>>> young_children.by(3)
```

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```
(age.i[0:3] >> '0:2', age.i[3:6] >> '3:5', age.i[6:7] >> '6')
>>> young_children.by(3, step=2)
(age.i[0:3] >> '0:2', age.i[2:5] >> '2:4', age.i[4:7] >> '4:6', age.i[6:7] >> '6')
>>> young_children.by(3, template='{start}-{end}')
(age.i[0:3] >> '0-2', age.i[3:6] >> '3-5', age.i[6:7] >> '6')
```

larray.LGroup.equals

`LGroup.equals(self, other)`

Checks if this group is equal to another group. Two groups are equal if they have the same group and axis names and correspond to the same labels.

Parameters

other [Group] Group to compare with.

Returns

bool True if the other group is equal to this group, False otherwise.

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a3')
>>> a02 = a['a0:a2'] >> 'group_a'
```

Same group names, axis names and labels

```
>>> a02.equals(a02)
True
```

Different group names (one is None)

```
>>> a02.equals(a['a0:a2'])
False
```

Different axis name

```
>>> other_axis = a.rename('other_name')
>>> a02.equals(other_axis['a0:a2'] >> 'group_a')
False
```

Different labels

```
>>> a02.equals(a['a1:a3'] >> 'group_a')
False
```

Mixing slice and list groups

```
>>> a['a0:a2'].equals(a['a0,a1,a2'])
True
```

Mixing LGroup and IGroup

```
>>> a['a0:a2'].equals(a.i[0:3])
True
```

larray.LGroup.translate

LGroup.**translate**(*self*, *bound=None*, *stop=False*)
compute position(s) of group

larray.LGroup.union

LGroup.**union**(*self*, *other*)
Returns (set) union of this label group and other.

Labels relative order will be kept intact, but only unique labels will be returned. Labels from this group will be before labels from other.

Parameters

other [Group or any sequence of labels] other labels

Returns

LSet

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a2')
>>> a['a0', 'a1'].union(a['a1', 'a2'])
a['a0', 'a1', 'a2'].set()
>>> a['a0', 'a1'].union('a1,a2')
a['a0', 'a1', 'a2'].set()
>>> a['a0', 'a1'].union(['a1', 'a2'])
a['a0', 'a1', 'a2'].set()
```

larray.LGroup.intersection

LGroup.**intersection**(*self*, *other*)
Returns (set) intersection of this label group and other.

In other words, this will return labels from this group which are also in other. Labels relative order will be kept intact, but only unique labels will be returned.

Parameters

other [Group or any sequence of labels] other labels

Returns

LSet

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a2')
>>> a['a0', 'a1'].intersection(a['a1', 'a2'])
a['a1'].set()
>>> a['a0', 'a1'].intersection('a1,a2')
a['a1'].set()
>>> a['a0', 'a1'].intersection(['a1', 'a2'])
a['a1'].set()
```

larray.LGroup.difference

LGroup.**difference**(*self*, *other*)

Returns (set) difference of this label group and other.

In other words, this will return labels from this group without those in other. Labels relative order will be kept intact, but only unique labels will be returned.

Parameters

other [Group or any sequence of labels] other labels

Returns

LSet

Examples

```
>>> from larray import Axis
>>> a = Axis('a=a0..a2')
>>> a['a0', 'a1'].difference(a['a1', 'a2'])
a['a0'].set()
>>> a['a0', 'a1'].difference('a1,a2')
a['a0'].set()
>>> a['a0', 'a1'].difference(['a1', 'a2'])
a['a0'].set()
```

larray.LGroup.containing

LGroup.**containing**(*self*, *substring*)

Returns a group with all the labels containing the specified substring.

Parameters

substring [str or Group] The substring to search for.

Returns

LGroup Group containing all the labels containing the substring.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
>>> group = people.startingwith('Bru')
>>> group
people['Bruce Wayne', 'Bruce Willis']
>>> group.containing('Will')
people['Bruce Willis']
```

larray.LGroup.startingwith

`LGroup.`**`startingwith`**`(`*self*, *prefix*`)`

Returns a group with the labels starting with the specified string.

Parameters

prefix [str or Group] The prefix to search for.

Returns

LGroup Group containing all the labels starting with the given string.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Arthur Dent', 'Harvey Dent'], 'people')
>>> group = people.endingwith('Dent')
>>> group
people['Arthur Dent', 'Harvey Dent']
>>> group.startingwith('Art')
people['Arthur Dent']
```

larray.LGroup.endingwith

`LGroup.`**`endingwith`**`(`*self*, *suffix*`)`

Returns a group with the labels ending with the specified string.

Parameters

suffix [str or Group] The suffix to search for.

Returns

LGroup Group containing all the labels ending with the given string.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
>>> group = people.startingwith('Bru')
>>> group
people['Bruce Wayne', 'Bruce Willis']
>>> people.endingwith('yne')
people['Bruce Wayne']
```

larray.LGroup.matching

LGroup.**matching**(*self*, *deprecated=None*, *pattern=None*, *regex=None*)
Returns a group with all the labels matching the specified pattern or regular expression.

Parameters

pattern [str or Group] Pattern to match.

- *?* matches any single character
- * matches any number of characters
- [seq] matches any character in seq
- [!seq] matches any character not in seq

To match any of the special characters above, wrap the character in brackets. For example, *[?]* matches the character *?*.

regex [str or Group] Regular expression pattern to match. Regular expressions are more powerful than what the simple patterns supported by the *pattern* argument but are also more complex to write. See Regular Expression for more details about how to build a regular expression pattern.

Returns

LGroup Group containing all the labels matching the pattern.

Examples

```
>>> from larray import Axis
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
```

Let us create a group with all names starting with B

```
>>> group = people.startingwith('B')
>>> group
people['Bruce Wayne', 'Bruce Willis']
```

Within that group, all labels containing any characters then W then any characters then s are given by

```
>>> group.matching(pattern='*W*s')
people['Bruce Willis']
```

Regular expressions are more powerful but usually harder to write and less readable. For example, here are the labels not containing the letter "i".

```
>>> group.matching(regex='^[^i]*$')
people['Bruce Wayne']
```

larray.LGroup.to_hdf

LGroup.**to_hdf**(*self*, *filepath*, *key=None*, *axis_key=None*)
Writes group to a HDF file.

A HDF file can contain multiple groups. The 'key' parameter is a unique identifier for the group. The 'axis_key' parameter is the unique identifier for the associated axis. The associated axis will be saved if not already present in the HDF file.

Parameters

filepath [str] Path where the hdf file has to be written.

key [str or Group, optional] Key (path) of the group within the HDF file (see Notes below). If None, the name of the group is used. Defaults to None.

axis_key [str, optional] Key (path) of the associated axis in the HDF file (see Notes below). If None, the name of the axis associated with the group is used. Defaults to None.

Notes

Objects stored in a HDF file can be grouped together in *HDF groups*. If an object 'my_obj' is stored in a HDF group 'my_group', the key associated with this object is then 'my_group/my_obj'. Be aware that a HDF group can have subgroups.

Examples

```
>>> from larray import Axis
>>> a = Axis("a=a0..a2")
>>> a.to_hdf('test.h5')
>>> a01 = a['a0,a1'] >> 'a01'
```

Save group

```
>>> # by default, the key is the name of the group
>>> # and axis_key the name of the associated axis
>>> a01.to_hdf('test.h5')                    # doctest: +SKIP
```

Save group with a specific key

```
>>> a01.to_hdf('test.h5', 'a_01')             # doctest: +SKIP
```

Save group in a specific HDF group

```
>>> a.to_hdf('test.h5', 'groups/a01')         # doctest: +SKIP
```

The associated axis is saved with the group if not already present in the HDF file

```
>>> b = Axis("b=b0..b2")
>>> b01 = b['b0,b1'] >> 'b01'
>>> # save both the group 'b01' and the associated axis 'b'
>>> b01.to_hdf('test.h5')                     # doctest: +SKIP
```

4.3.3 LSet

LSet(key[, name, axis])	Label set.

larray.LSet

class larray.**LSet**(*key*, *name=None*, *axis=None*)
Label set.

Represents a set of (unique) labels of an axis.

Parameters

key [key] Anything usable for indexing. A key should be either sequence of labels, a slice with label bounds or a string.

name [str, optional] Name of the set.

axis [int, str, Axis, optional] Axis for set.

Examples

```
>>> from larray import Axis
>>> letters = Axis('letters=a..z')
>>> abc = letters[':c'].set() >> 'abc'
>>> abc
letters['a', 'b', 'c'].set() >> 'abc'
>>> abc & letters['b:d']
letters['b', 'c'].set()
```

__init__(*self*, *key*, *name=None*, *axis=None*)
Initialize self. See help(type(self)) for accurate signature.

Methods

`__init__`(self, key[, name, axis])	Initialize self.
`by`(self, length[, step, template])	Split group into several groups of specified length.
`containing`(self, substring)	Returns a group with all the labels containing the specified substring.
`difference`(self, other)	
`endingwith`(self, suffix)	Returns a group with the labels ending with the specified string.
`equals`(self, other)	Checks if this group is equal to another group.
`eval`(self)	Translate key to labels, if it is not already, expanding slices in the process.
`intersection`(self, other)	
`matching`(self[, deprecated, pattern, regex])	Returns a group with all the labels matching the specified pattern or regular expression.
`named`(self, name)	Returns group with a different name.
`retarget_to`(self, target_axis)	Retarget group to another axis.
`set`(self)	Creates LSet from this group
`startingwith`(self, prefix)	Returns a group with the labels starting with the specified string.
`to_hdf`(self, filepath[, key, axis_key])	Writes group to a HDF file.
`to_label`(self)	Translate key to labels, if it is not already
`translate`(self[, bound, stop])	compute position(s) of group
`union`(self, other)	

Continued on next page

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with_axis(self, axis)	Returns group with a different axis.

Attributes

axis
format_string
key
name

4.3.4 AxisCollection

AxisCollection([axes])

larray.AxisCollection

class larray.**AxisCollection**(*axes=None*)

__init__(*self*, *axes=None*)
Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self[, axes])	Initialize self.
align(self, other[, join, axes])	Align this axis collection with another.
append(self, axis)	Appends axis at the end of the collection.
axis_id(self, axis)	Returns the id of an axis.
check_compatible(self, axes)	Checks if axes passed as argument are compatible with those contained in the collection.
combine_axes(self[, axes, sep, wildcard, …])	Combine several axes into one.
copy(self)	Returns a copy.
extend(self, axes[, validate, replace_wildcards])	Extends the collection by appending the axes from *axes*.
get(self, key[, default, name])	Returns axis corresponding to key.
get_all(self, key)	Returns all axes from key if present and length 1 wildcard axes otherwise.
get_by_pos(self, key, i)	Returns axis corresponding to a key, or to position i if the key has no name and key object not found.
index(self, axis[, compatible])	Returns the index of axis.
insert(self, index, axis)	Inserts axis before index.
isaxis(self, value)	Tests if input is an Axis object or the name of an axis contained in self.
iter_labels(self[, axes, ascending])	Returns a view of the axes labels.
keys(self)	Returns list of all axis names.
pop(self[, axis])	Removes and returns an axis.
rename(self[, renames, to])	Renames axes of the collection.
replace(self[, axes_to_replace, new_axis, …])	Replace one, several or all axes of the collection.
set_labels(self[, axis, labels, inplace])	Replaces the labels of one or several axes.

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split_axes(self[, axes, sep, names, regex])	Split axes and returns a new collection
split_axis(*args, **kwargs)	
union(self, *args, **kwargs)	
without(self, axes)	Returns a new collection without some axes.

Attributes

display_names	Returns the list of (display) names of the axes.
ids	Returns the list of ids of the axes.
info	Describes the collection (shape and labels for each axis).
labels	Returns the list of labels of the axes.
names	Returns the list of (raw) names of the axes.
ndim	
shape	Returns the shape of the collection.
size	Returns the size of the collection, i.e.

AxisCollection.names	Returns the list of (raw) names of the axes.
AxisCollection.display_names	Returns the list of (display) names of the axes.
AxisCollection.labels	Returns the list of labels of the axes.
AxisCollection.shape	Returns the shape of the collection.
AxisCollection.size	Returns the size of the collection, i.e.
AxisCollection.info	Describes the collection (shape and labels for each axis).
AxisCollection.copy(self)	Returns a copy.

larray.AxisCollection.names

property AxisCollection.**names**

Returns the list of (raw) names of the axes.

Returns

list List of names of the axes.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> AxisCollection([age, sex, time]).names
['age', 'sex', 'time']
```

larray.AxisCollection.display_names

property AxisCollection.**display_names**

Returns the list of (display) names of the axes.

Returns

list List of names of the axes. Wildcard axes are displayed with an attached *. Anonymous axes (name = None) are replaced by their position wrapped in braces.

Examples

```
>>> a = Axis(['a1', 'a2'], 'a')
>>> b = Axis(2, 'b')
>>> c = Axis(['c1', 'c2'])
>>> d = Axis(3)
>>> AxisCollection([a, b, c, d]).display_names
['a', 'b*', '{2}', '{3}*']
```

larray.AxisCollection.labels

property AxisCollection.**labels**

Returns the list of labels of the axes.

Returns

list List of labels of the axes.

Examples

```
>>> age = Axis(range(10), 'age')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> AxisCollection([age, time]).labels  # doctest: +NORMALIZE_WHITESPACE
[array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9]),
 array([2007, 2008, 2009, 2010])]
```

larray.AxisCollection.shape

property AxisCollection.**shape**

Returns the shape of the collection.

Returns

tuple Tuple of lengths of axes.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> AxisCollection([age, sex, time]).shape
(20, 2, 4)
```

larray.AxisCollection.size

property AxisCollection.**size**

Returns the size of the collection, i.e. the number of elements of the array.

Returns

int Number of elements of the array.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> AxisCollection([age, sex, time]).size
160
```

larray.AxisCollection.info

property `AxisCollection.info`

Describes the collection (shape and labels for each axis).

Returns

str Description of the AxisCollection (shape and labels for each axis).

Examples

```
>>> age = Axis(20, 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> AxisCollection([age, sex, time]).info
20 x 2 x 4
 age* [20]: 0 1 2 ... 17 18 19
 sex [2]: 'M' 'F'
 time [4]: 2007 2008 2009 2010
```

larray.AxisCollection.copy

`AxisCollection.copy(self)`

Returns a copy.

Searching

AxisCollection.keys(self)	Returns list of all axis names.
AxisCollection.index(self, axis[, compatible])	Returns the index of axis.
AxisCollection.axis_id(self, axis)	Returns the id of an axis.
AxisCollection.ids	Returns the list of ids of the axes.
AxisCollection.iter_labels(self[, axes, …])	Returns a view of the axes labels.

larray.AxisCollection.keys

`AxisCollection.keys(self)`

Returns list of all axis names.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> AxisCollection([age, sex, time]).keys()
['age', 'sex', 'time']
```

larray.AxisCollection.index

AxisCollection.**index**(*self*, *axis*, *compatible=False*)

Returns the index of axis.

axis can be a name or an Axis object (or an index). If the Axis object itself exists in the list, index() will return it. Otherwise, it will return the index of the local axis with the same name than the key (whether it is compatible or not).

Parameters

axis [Axis or int or str] Can be the axis itself or its position (returned if represents a valid index) or its name.

compatible [bool, optional] If axis is an Axis, whether to find an exact match (using Axis.equals) or any compatible axis (using Axis.iscompatible)

Returns

int Index of the axis.

Raises

ValueError Raised if the axis is not present.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection([age, sex, time])
>>> col.index(time)
2
>>> col.index('sex')
1
```

larray.AxisCollection.axis_id

AxisCollection.**axis_id**(*self*, *axis*)

Returns the id of an axis.

Returns

str or int Id of axis, which is its name if defined and its position otherwise.

Examples

```
>>> a = Axis(2, 'a')
>>> b = Axis(2)
>>> c = Axis(2, 'c')
>>> col = AxisCollection([a, b, c])
>>> col.axis_id(a)
'a'
>>> col.axis_id(b)
1
>>> col.axis_id(c)
'c'
```

larray.AxisCollection.ids

property AxisCollection.**ids**

Returns the list of ids of the axes.

Returns

list List of ids of the axes.

See also:

axis_id

Examples

```
>>> a = Axis(2, 'a')
>>> b = Axis(2)
>>> c = Axis(2, 'c')
>>> AxisCollection([a, b, c]).ids
['a', 1, 'c']
```

larray.AxisCollection.iter_labels

AxisCollection.**iter_labels**(*self*, *axes=None*, *ascending=True*)

Returns a view of the axes labels.

Parameters

axes [int, str or Axis or tuple of them, optional] Axis or axes along which to iterate and in which order. Defaults to None (all axes in the order they are in the collection).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

Returns

Sequence An object you can iterate (loop) on and index by position.

Examples

```
>>> from larray import ndtest
>>> axes = ndtest((2, 2)).axes
>>> axes
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1'], 'b')
])
>>> axes.iter_labels()[0]
(a.i[0], b.i[0])
>>> for index in axes.iter_labels():
...     print(index)
(a.i[0], b.i[0])
(a.i[0], b.i[1])
(a.i[1], b.i[0])
(a.i[1], b.i[1])
>>> axes.iter_labels(ascending=False)[0]
(a.i[1], b.i[1])
>>> for index in axes.iter_labels(ascending=False):
...     print(index)
(a.i[1], b.i[1])
(a.i[1], b.i[0])
(a.i[0], b.i[1])
(a.i[0], b.i[0])
>>> axes.iter_labels(('b', 'a'))[0]
(b.i[0], a.i[0])
>>> for index in axes.iter_labels(('b', 'a')):
...     print(index)
(b.i[0], a.i[0])
(b.i[0], a.i[1])
(b.i[1], a.i[0])
(b.i[1], a.i[1])
>>> axes.iter_labels('b')[0]
(b.i[0],)
>>> for index in axes.iter_labels('b'):
...     print(index)
(b.i[0],)
(b.i[1],)
```

Modifying/Selecting

`AxisCollection.get`(self, key[, default, name])	Returns axis corresponding to key.
`AxisCollection.get_by_pos`(self, key, i)	Returns axis corresponding to a key, or to position i if the key has no name and key object not found.
`AxisCollection.get_all`(self, key)	Returns all axes from key if present and length 1 wildcard axes otherwise.
`AxisCollection.pop`(self[, axis])	Removes and returns an axis.
`AxisCollection.append`(self, axis)	Appends axis at the end of the collection.
`AxisCollection.extend`(self, axes[, …])	Extends the collection by appending the axes from *axes*.
`AxisCollection.insert`(self, index, axis)	Inserts axis before index.
`AxisCollection.rename`(self[, renames, to])	Renames axes of the collection.
`AxisCollection.replace`(self[, …])	Replace one, several or all axes of the collection.

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AxisCollection.set_labels(self[, axis, ...])	Replaces the labels of one or several axes.
AxisCollection.without(self, axes)	Returns a new collection without some axes.
AxisCollection.combine_axes(self[, axes, ...])	Combine several axes into one.
AxisCollection.split_axes(self[, axes, sep, ...])	Split axes and returns a new collection
AxisCollection.align(self, other[, join, axes])	Align this axis collection with another.

larray.AxisCollection.get

AxisCollection.**get**(*self*, *key*, *default=None*, *name=None*)

Returns axis corresponding to key. If not found, the argument *name* is used to create a new Axis. If *name* is None, the *default* axis is then returned.

Parameters

key [key] Key corresponding to an axis of the current AxisCollection.

default [axis, optional] Default axis to return if key doesn't correspond to any axis of the collection and argument *name* is None.

name [str, optional] If key doesn't correspond to any axis of the collection, a new Axis with this name is created and returned.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection([age, time])
>>> col.get('time')
Axis([2007, 2008, 2009, 2010], 'time')
>>> col.get('sex', sex)
Axis(['M', 'F'], 'sex')
>>> col.get('nb_children', None, 'nb_children')
Axis(1, 'nb_children')
```

larray.AxisCollection.get_by_pos

AxisCollection.**get_by_pos**(*self*, *key*, *i*)

Returns axis corresponding to a key, or to position i if the key has no name and key object not found.

Parameters

key [key] Key corresponding to an axis.

i [int] Position of the axis (used only if search by key failed).

Returns

Axis Axis corresponding to the key or the position i.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection([age, sex, time])
>>> col.get_by_pos('sex', 1)
Axis(['M', 'F'], 'sex')
```

larray.AxisCollection.get_all

AxisCollection.**get_all**(*self*, *key*)

Returns all axes from key if present and length 1 wildcard axes otherwise.

Parameters

key [AxisCollection]

Returns

AxisCollection

Raises

AssertionError Raised if the input key is not an AxisCollection object.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> city = Axis(['London', 'Paris', 'Rome'], 'city')
>>> col = AxisCollection([age, sex, time])
>>> col2 = AxisCollection([age, city, time])
>>> col.get_all(col2)
AxisCollection([
    Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19],
↪'age'),
    Axis(1, 'city'),
    Axis([2007, 2008, 2009, 2010], 'time')
])
```

larray.AxisCollection.pop

AxisCollection.**pop**(*self*, *axis=-1*)

Removes and returns an axis.

Parameters

axis [key, optional] Axis to remove and return. Default value is -1 (last axis).

Returns

Axis If no argument is provided, the last axis is removed and returned.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection([age, sex, time])
>>> col.pop('age')
Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19], 'age
↪')
>>> col
AxisCollection([
    Axis(['M', 'F'], 'sex'),
    Axis([2007, 2008, 2009, 2010], 'time')
])
>>> col.pop()
Axis([2007, 2008, 2009, 2010], 'time')
```

larray.AxisCollection.append

`AxisCollection.append(self, axis)`
Appends axis at the end of the collection.

Parameters

axis [Axis] Axis to append.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection([age, sex])
>>> col.append(time)
>>> col
AxisCollection([
    Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19],
↪'age'),
    Axis(['M', 'F'], 'sex'),
    Axis([2007, 2008, 2009, 2010], 'time')
])
```

larray.AxisCollection.extend

`AxisCollection.extend(self, axes, validate=True, replace_wildcards=False)`
Extends the collection by appending the axes from *axes*.

Parameters

axes [sequence of Axis (list, tuple, AxisCollection)]

validate [bool, optional]

replace_wildcards [bool, optional]

Raises

TypeError Raised if *axes* is not a sequence of Axis (list, tuple or AxisCollection)

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection(age)
>>> col.extend([sex, time])
>>> col
AxisCollection([
    Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19],
↪'age'),
    Axis(['M', 'F'], 'sex'),
    Axis([2007, 2008, 2009, 2010], 'time')
])
```

larray.AxisCollection.insert

AxisCollection.**insert**(*self*, *index*, *axis*)
Inserts axis before index.

Parameters

index [int] position of the inserted axis.

axis [Axis] axis to insert.

Examples

```
>>> age = Axis(range(20), 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009, 2010], 'time')
>>> col = AxisCollection([age, time])
>>> col.insert(1, sex)
>>> col
AxisCollection([
    Axis([0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19],
↪'age'),
    Axis(['M', 'F'], 'sex'),
    Axis([2007, 2008, 2009, 2010], 'time')
])
```

larray.AxisCollection.rename

AxisCollection.**rename**(*self*, *renames=None*, *to=None*, ***kwargs*)
Renames axes of the collection.

Parameters

renames [axis ref or dict {axis ref: str} or list of tuple (axis ref, str), optional] Renames to apply. If a single axis reference is given, the *to* argument must be used.

to [str or Axis, optional] New name if *renames* contains a single axis reference.

****kwargs** [str or Axis] New name for each axis given as a keyword argument.

Returns

AxisCollection collection with axes renamed.

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> axes = AxisCollection([nat, sex])
>>> axes
AxisCollection([
    Axis(['BE', 'FO'], 'nat'),
    Axis(['M', 'F'], 'sex')
])
>>> axes.rename(nat, 'nat2')
AxisCollection([
    Axis(['BE', 'FO'], 'nat2'),
    Axis(['M', 'F'], 'sex')
])
>>> axes.rename(nat='nat2', sex='sex2')
AxisCollection([
    Axis(['BE', 'FO'], 'nat2'),
    Axis(['M', 'F'], 'sex2')
])
>>> axes.rename([('nat', 'nat2'), ('sex', 'sex2')])
AxisCollection([
    Axis(['BE', 'FO'], 'nat2'),
    Axis(['M', 'F'], 'sex2')
])
>>> axes.rename({'nat': 'nat2', 'sex': 'sex2'})
AxisCollection([
    Axis(['BE', 'FO'], 'nat2'),
    Axis(['M', 'F'], 'sex2')
])
```

larray.AxisCollection.replace

`AxisCollection.`**`replace`**(*self*, *axes_to_replace=None*, *new_axis=None*, *inplace=False*, ***kwargs*)
Replace one, several or all axes of the collection.

Parameters

axes_to_replace [axis ref or dict {axis ref: axis} or list of tuple (axis ref, axis)]

or list of Axis or AxisCollection, optional

Axes to replace. If a single axis reference is given, the *new_axis* argument must be provided. If a list of Axis or an AxisCollection is given, all axes will be replaced by the new ones. In that case, the number of new axes must match the number of the old ones. Defaults to None.

new_axis [axis ref, optional] New axis if *axes_to_replace* contains a single axis reference. Defaults to None.

inplace [bool, optional] Whether or not to modify the original object or return a new AxisCollection and leave the original intact. Defaults to False.

****kwargs** [Axis] New axis for each axis to replace given as a keyword argument.

Returns

AxisCollection AxisCollection with axes replaced.

Examples

```
>>> from larray import ndtest
>>> axes = ndtest((2, 3)).axes
>>> axes
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
>>> row = Axis(['r0', 'r1'], 'row')
>>> column = Axis(['c0', 'c1', 'c2'], 'column')
```

Replace one axis (second argument *new_axis* must be provided)

```
>>> axes.replace(X.a, row)  # doctest: +SKIP
>>> # or
>>> axes.replace(X.a, "row=r0,r1")
AxisCollection([
    Axis(['r0', 'r1'], 'row'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
```

Replace several axes (keywords, list of tuple or dictionary)

```
>>> axes.replace(a=row, b=column)  # doctest: +SKIP
>>> # or
>>> axes.replace(a="row=r0,r1", b="column=c0,c1,c2")  # doctest: +SKIP
>>> # or
>>> axes.replace([(X.a, row), (X.b, column)])  # doctest: +SKIP
>>> # or
>>> axes.replace({X.a: row, X.b: column})
AxisCollection([
    Axis(['r0', 'r1'], 'row'),
    Axis(['c0', 'c1', 'c2'], 'column')
])
```

Replace all axes (list of axes or AxisCollection)

```
>>> axes.replace([row, column])
AxisCollection([
    Axis(['r0', 'r1'], 'row'),
    Axis(['c0', 'c1', 'c2'], 'column')
])
>>> arr = ndtest([row, column])
>>> axes.replace(arr.axes)
AxisCollection([
    Axis(['r0', 'r1'], 'row'),
    Axis(['c0', 'c1', 'c2'], 'column')
])
```

larray.AxisCollection.set_labels

AxisCollection.**set_labels**(*self*, *axis=None*, *labels=None*, *inplace=False*, ***kwargs*)

Replaces the labels of one or several axes.

Parameters

axis [string or Axis or dict] Axis for which we want to replace labels, or mapping {axis: changes} where changes can either be the complete list of labels, a mapping {old_label: new_label} or a function to transform labels. If there is no ambiguity (two or more axes have the same labels), *axis* can be a direct mapping {old_label: new_label}.

labels [int, str, iterable or mapping or function, optional] Integer or list of values usable as the collection of labels for an Axis. If this is mapping, it must be {old_label: new_label}. If it is a function, it must be a function accepting a single argument (a label) and returning a single value. This argument must not be used if axis is a mapping.

inplace [bool, optional] Whether or not to modify the original object or return a new AxisCollection and leave the original intact. Defaults to False.

****kwargs :** *axis*'='*labels* for each axis you want to set labels.

Returns

AxisCollection AxisCollection with modified labels.

Examples

```
>>> from larray import ndtest
>>> axes = AxisCollection('nat=BE,FO;sex=M,F')
>>> axes
AxisCollection([
    Axis(['BE', 'FO'], 'nat'),
    Axis(['M', 'F'], 'sex')
])
>>> axes.set_labels('sex', ['Men', 'Women'])
AxisCollection([
    Axis(['BE', 'FO'], 'nat'),
    Axis(['Men', 'Women'], 'sex')
])
```

when passing a single string as labels, it will be interpreted to create the list of labels, so that one can use the same syntax than during axis creation.

```
>>> axes.set_labels('sex', 'Men,Women')
AxisCollection([
    Axis(['BE', 'FO'], 'nat'),
    Axis(['Men', 'Women'], 'sex')
])
```

to replace only some labels, one must give a mapping giving the new label for each label to replace

```
>>> axes.set_labels('sex', {'M': 'Men'})
AxisCollection([
    Axis(['BE', 'FO'], 'nat'),
    Axis(['Men', 'F'], 'sex')
])
```

to transform labels by a function, use any function accepting and returning a single argument:

```
>>> axes.set_labels('nat', str.lower)
AxisCollection([
    Axis(['be', 'fo'], 'nat'),
    Axis(['M', 'F'], 'sex')
])
```

to replace labels for several axes at the same time, one should give a mapping giving the new labels for each changed axis

```
>>> axes.set_labels({'sex': 'Men,Women', 'nat': 'Belgian,Foreigner'})
AxisCollection([
    Axis(['Belgian', 'Foreigner'], 'nat'),
    Axis(['Men', 'Women'], 'sex')
])
```

or use keyword arguments

```
>>> axes.set_labels(sex='Men,Women', nat='Belgian,Foreigner')
AxisCollection([
    Axis(['Belgian', 'Foreigner'], 'nat'),
    Axis(['Men', 'Women'], 'sex')
])
```

one can also replace some labels in several axes by giving a mapping of mappings

```
>>> axes.set_labels({'sex': {'M': 'Men'}, 'nat': {'BE': 'Belgian'}})
AxisCollection([
    Axis(['Belgian', 'FO'], 'nat'),
    Axis(['Men', 'F'], 'sex')
])
```

when there is no ambiguity (two or more axes have the same labels), it is possible to give a mapping between old and new labels

```
>>> axes.set_labels({'M': 'Men', 'BE': 'Belgian'})
AxisCollection([
    Axis(['Belgian', 'FO'], 'nat'),
    Axis(['Men', 'F'], 'sex')
])
```

larray.AxisCollection.without

`AxisCollection.`**`without`**(*self*, *axes*)

Returns a new collection without some axes.

You can use a comma separated list of names.

Parameters

axes [int, str, Axis or sequence of those] Axes to not include in the returned AxisCollection. In case of string, axes are separated by a comma and no whitespace is accepted.

Returns

AxisCollection New collection without some axes.

Notes

Set operation so axes can contain axes not present in self

Examples

```
>>> age = Axis('age=0..5')
>>> sex = Axis('sex=M,F')
>>> time = Axis('time=2015..2017')
>>> col = AxisCollection([age, sex, time])
>>> col.without([age, sex])
AxisCollection([
    Axis([2015, 2016, 2017], 'time')
])
>>> col.without(0)
AxisCollection([
    Axis(['M', 'F'], 'sex'),
    Axis([2015, 2016, 2017], 'time')
])
>>> col.without('sex,time')
AxisCollection([
    Axis([0, 1, 2, 3, 4, 5], 'age')
])
```

larray.AxisCollection.combine_axes

`AxisCollection.combine_axes`(*self*, *axes=None*, *sep='_'*, *wildcard=False*, *front_if_spread=False*)
Combine several axes into one.

Parameters

axes [tuple, list, AxisCollection of axes or list of combination of those or dict, optional] axes to combine. Tuple, list or AxisCollection will combine several axes into one. To chain several axes combinations, pass a list of tuple/list/AxisCollection of axes. To set the name(s) of resulting axis(es), use a {(axes, to, combine): 'new_axis_name'} dictionary. Defaults to all axes.

sep [str, optional] delimiter to use for combining. Defaults to '_'.

wildcard [bool, optional] whether or not to produce a wildcard axis even if the axes to combine are not. This is much faster, but loose axes labels.

front_if_spread [bool, optional] whether or not to move the combined axis at the front (it will be the first axis) if the combined axes are not next to each other.

Returns

AxisCollection New AxisCollection with combined axes.

Examples

```
>>> axes = AxisCollection('a=a0,a1;b=b0..b2')
>>> axes
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
```

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```
    Axis(['b0', 'b1', 'b2'], 'b')
])
>>> axes.combine_axes()
AxisCollection([
    Axis(['a0_b0', 'a0_b1', 'a0_b2', 'a1_b0', 'a1_b1', 'a1_b2'], 'a_b')
])
>>> axes.combine_axes(sep='/')
AxisCollection([
    Axis(['a0/b0', 'a0/b1', 'a0/b2', 'a1/b0', 'a1/b1', 'a1/b2'], 'a/b')
])
>>> axes += AxisCollection('c=c0..c2;d=d0,d1')
>>> axes.combine_axes(('a', 'c'))
AxisCollection([
    Axis(['a0_c0', 'a0_c1', 'a0_c2', 'a1_c0', 'a1_c1', 'a1_c2'], 'a_c'),
    Axis(['b0', 'b1', 'b2'], 'b'),
    Axis(['d0', 'd1'], 'd')
])
>>> axes.combine_axes({('a', 'c'): 'ac'})
AxisCollection([
    Axis(['a0_c0', 'a0_c1', 'a0_c2', 'a1_c0', 'a1_c1', 'a1_c2'], 'ac'),
    Axis(['b0', 'b1', 'b2'], 'b'),
    Axis(['d0', 'd1'], 'd')
])
```

make several combinations at once

```
>>> axes.combine_axes([('a', 'c'), ('b', 'd')])
AxisCollection([
    Axis(['a0_c0', 'a0_c1', 'a0_c2', 'a1_c0', 'a1_c1', 'a1_c2'], 'a_c'),
    Axis(['b0_d0', 'b0_d1', 'b1_d0', 'b1_d1', 'b2_d0', 'b2_d1'], 'b_d')
])
>>> axes.combine_axes({('a', 'c'): 'ac', ('b', 'd'): 'bd'})
AxisCollection([
    Axis(['a0_c0', 'a0_c1', 'a0_c2', 'a1_c0', 'a1_c1', 'a1_c2'], 'ac'),
    Axis(['b0_d0', 'b0_d1', 'b1_d0', 'b1_d1', 'b2_d0', 'b2_d1'], 'bd')
])
```

larray.AxisCollection.split_axes

`AxisCollection.`**`split_axes`**(*self*, *axes=None*, *sep='_'*, *names=None*, *regex=None*)

Split axes and returns a new collection

The split axes are inserted where the combined axis was.

Parameters

axes [int, str, Axis or any combination of those, optional] axes to split. All labels *must* contain the given delimiter string. To split several axes at once, pass a list or tuple of axes to split. To set the names of resulting axes, use a {'axis_to_split': (new, axes)} dictionary. Defaults to all axes whose name contains the *sep* delimiter.

sep [str, optional] delimiter to use for splitting. Defaults to '_'. When *regex* is provided, the delimiter is only used on *names* if given as one string or on axis name if *names* is None.

names [str or list of str, optional] names of resulting axes. Defaults to None.

regex [str, optional] use regex instead of delimiter to split labels. Defaults to None.

Returns

AxisCollection

See also:

Axis.split

LArray.split_axes

Examples

```
>>> col = AxisCollection('a=a0,a1;b=b0..b2')
>>> col
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
>>> combined = col.combine_axes()
>>> combined
AxisCollection([
    Axis(['a0_b0', 'a0_b1', 'a0_b2', 'a1_b0', 'a1_b1', 'a1_b2'], 'a_b')
])
>>> combined.split_axes()
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
```

Split labels using regex

```
>>> combined = AxisCollection('a_b = a0b0..a1b2')
>>> combined
AxisCollection([
    Axis(['a0b0', 'a0b1', 'a0b2', 'a1b0', 'a1b1', 'a1b2'], 'a_b')
])
>>> combined.split_axes('a_b', regex=r'(\w{2})(\w{2})')
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
```

Split several axes at once

```
>>> combined = AxisCollection('a_b = a0_b0..a1_b1; c_d = c0_d0..c1_d1')
>>> combined
AxisCollection([
    Axis(['a0_b0', 'a0_b1', 'a1_b0', 'a1_b1'], 'a_b'),
    Axis(['c0_d0', 'c0_d1', 'c1_d0', 'c1_d1'], 'c_d')
])
>>> # equivalent to combined.split_axes() which split all axes
>>> # containing the delimiter defined by the argument `sep`
>>> combined.split_axes(['a_b', 'c_d'])
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1'], 'b'),
    Axis(['c0', 'c1'], 'c'),
```

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```
    Axis(['d0', 'd1'], 'd')
])
>>> combined.split_axes({'a_b': ('A', 'B'), 'c_d': ('C', 'D')})
AxisCollection([
    Axis(['a0', 'a1'], 'A'),
    Axis(['b0', 'b1'], 'B'),
    Axis(['c0', 'c1'], 'C'),
    Axis(['d0', 'd1'], 'D')
])
```

larray.AxisCollection.align

`AxisCollection.align`(*self*, *other*, *join='outer'*, *axes=None*)

Align this axis collection with another.

This ensures all common axes are compatible.

Parameters

other [AxisCollection]

join [{'outer', 'inner', 'left', 'right', 'exact'}, optional] Defaults to 'outer'.

axes [AxisReference or sequence of them, optional] Axes to align. Need to be valid in both arrays. Defaults to None (all common axes). This must be specified when mixing anonymous and non-anonymous axes.

Returns

(left, right) [(AxisCollection, AxisCollection)] Aligned collections

See also:

LArray.align

Examples

```
>>> col1 = AxisCollection("a=a0..a1;b=b0..b2")
>>> col1
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
>>> col2 = AxisCollection("a=a0..a2;c=c0..c0;b=b0..b1")
>>> col2
AxisCollection([
    Axis(['a0', 'a1', 'a2'], 'a'),
    Axis(['c0'], 'c'),
    Axis(['b0', 'b1'], 'b')
])
>>> aligned1, aligned2 = col1.align(col2)
>>> aligned1
AxisCollection([
    Axis(['a0', 'a1', 'a2'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
```

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```
>>> aligned2
AxisCollection([
    Axis(['a0', 'a1', 'a2'], 'a'),
    Axis(['c0'], 'c'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
```

Using anonymous axes

```
>>> col1 = AxisCollection("a0..a1;b0..b2")
>>> col1
AxisCollection([
    Axis(['a0', 'a1'], None),
    Axis(['b0', 'b1', 'b2'], None)
])
>>> col2 = AxisCollection("a0..a2;b0..b1;c0..c0")
>>> col2
AxisCollection([
    Axis(['a0', 'a1', 'a2'], None),
    Axis(['b0', 'b1'], None),
    Axis(['c0'], None)
])
>>> aligned1, aligned2 = col1.align(col2)
>>> aligned1
AxisCollection([
    Axis(['a0', 'a1', 'a2'], None),
    Axis(['b0', 'b1', 'b2'], None)
])
>>> aligned2
AxisCollection([
    Axis(['a0', 'a1', 'a2'], None),
    Axis(['b0', 'b1', 'b2'], None),
    Axis(['c0'], None)
])
```

Testing

AxisCollection.isaxis(self, value)	Tests if input is an Axis object or the name of an axis contained in self.
AxisCollection.check_compatible(self, axes)	Checks if axes passed as argument are compatible with those contained in the collection.

larray.AxisCollection.isaxis

AxisCollection.**isaxis**(*self*, *value*)

Tests if input is an Axis object or the name of an axis contained in self.

Parameters

value [Axis or str] Input axis or string

Returns

bool True if input is an Axis object or the name of an axis contained in the current AxisCollection instance, False otherwise.

Examples

```
>>> a = Axis('a=a0,a1')
>>> b = Axis('b=b0,b1')
>>> col = AxisCollection([a, b])
>>> col.isaxis(a)
True
>>> col.isaxis('b')
True
>>> col.isaxis('c')
False
```

larray.AxisCollection.check_compatible

AxisCollection.**check_compatible**(*self*, *axes*)

Checks if axes passed as argument are compatible with those contained in the collection. Raises ValueError if not.

See also:

Axis.iscompatible

4.3.5 LArray

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Overview

LArray(data[, axes, title, meta, dtype])	A LArray object represents a multidimensional, homogeneous array of fixed-size items with labeled axes.

larray.LArray

class larray.**LArray**(*data*, *axes=None*, *title=None*, *meta=None*, *dtype=None*)

A LArray object represents a multidimensional, homogeneous array of fixed-size items with labeled axes.

The function `aslarray()` can be used to convert a NumPy array or Pandas DataFrame into a LArray.

Parameters

data [scalar, tuple, list or NumPy ndarray] Input data.

axes [collection (tuple, list or AxisCollection) of axes (int, str or Axis), optional] Axes.

title [str, optional] Deprecated. See 'meta' below.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, . . .) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

dtype [type, optional] Datatype for the array. Defaults to None (inferred from the data).

Warning: Metadata is not kept when actions or methods are applied on an array except for operations modifying the object in-place, such as: *pop[age < 10] = 0*. Do not add metadata to an array if you know you will apply actions or methods on it before dumping it.

See also:

sequence Create a LArray by sequentially applying modifications to the array along axis.

ndtest Create a test LArray with increasing elements.

zeros Create a LArray, each element of which is zero.

ones Create a LArray, each element of which is 1.

full Create a LArray filled with a given value.

empty Create a LArray, but leave its allocated memory unchanged (i.e., it contains "garbage").

Examples

```
>>> age = Axis([10, 11, 12], 'age')
>>> sex = Axis('sex=M,F')
>>> time = Axis([2007, 2008, 2009], 'time')
>>> axes = [age, sex, time]
>>> data = np.zeros((len(axes), len(sex), len(time)))
```

```
>>> LArray(data, axes)
age  sex\time  2007  2008  2009
 10         M   0.0   0.0   0.0
 10         F   0.0   0.0   0.0
 11         M   0.0   0.0   0.0
 11         F   0.0   0.0   0.0
```

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```
 12          M    0.0    0.0    0.0
 12          F    0.0    0.0    0.0
>>> # with metadata (Python <= 3.5)
>>> arr = LArray(data, axes, meta=[('title', 'my title'), ('author', 'John Smith
↪')])
>>> # with metadata (Python 3.6+)
>>> arr = LArray(data, axes, meta=Metadata(title='my title', author='John Smith
↪'))  # doctest: +SKIP
```

Array creation functions

```
>>> full(axes, 10.0)
age  sex\time  2007  2008  2009
 10          M  10.0  10.0  10.0
 10          F  10.0  10.0  10.0
 11          M  10.0  10.0  10.0
 11          F  10.0  10.0  10.0
 12          M  10.0  10.0  10.0
 12          F  10.0  10.0  10.0
>>> arr = empty(axes)
>>> arr['F'] = 1.0
>>> arr['M'] = -1.0
>>> arr
age  sex\time  2007  2008  2009
 10          M  -1.0  -1.0  -1.0
 10          F   1.0   1.0   1.0
 11          M  -1.0  -1.0  -1.0
 11          F   1.0   1.0   1.0
 12          M  -1.0  -1.0  -1.0
 12          F   1.0   1.0   1.0
>>> bysex = sequence(sex, initial=-1, inc=2)
>>> bysex
sex   M  F
     -1  1
>>> sequence(age, initial=10, inc=bysex)
sex\age  10  11  12
      M  10   9   8
      F  10  11  12
```

Attributes

data [NumPy ndarray] Data.

axes [AxisCollection] Axes.

meta [Metadata] Returns metadata of the array.

__init__(*self*, *data*, *axes=None*, *title=None*, *meta=None*, *dtype=None*)
Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self, data[, axes, title, meta, dtype])	Initialize self.

Continued on next page

Table 28 – continued from previous page

align(self, other[, join, fill_value, axes])	Align two arrays on their axes with the specified join method.
all(*axes_and_groups[, out, skipna, keepaxes])	Test whether all selected elements evaluate to True.
all_by(*axes_and_groups[, out, skipna, keepaxes])	Test whether all selected elements evaluate to True.
any(*axes_and_groups[, out, skipna, keepaxes])	Test whether any selected elements evaluate to True.
any_by(*axes_and_groups[, out, skipna, keepaxes])	Test whether any selected elements evaluate to True.
append(self, axis, value[, label])	Adds an array to self along an axis.
apply(self, transform, *args, **kwargs)	Apply a transformation function to array elements.
apply_map(self, mapping[, dtype])	Apply a transformation mapping to array elements.
argmax(*args, **kwargs)	
argmin(*args, **kwargs)	
argsort(*args, **kwargs)	
as_table(self[, maxlines, edgeitems, light, . . .])	Deprecated.
astype(dtype[, order, casting, subok, copy])	Copy of the array, cast to a specified type.
broadcast_with(self, target)	Returns an array that is (NumPy) broadcastable with target.
clip(self[, minval, maxval, out])	Clip (limit) the values in an array.
combine_axes(self[, axes, sep, wildcard])	Combine several axes into one.
compact(self)	Detects and removes "useless" axes (ie axes for which values are constant over the whole axis)
copy(self)	Returns a copy of the array.
cumprod(self[, axis])	Returns the cumulative product of array elements.
cumsum(self[, axis])	Returns the cumulative sum of array elements along an axis.
describe(self, *args, **kwargs)	Descriptive summary statistics, excluding NaN values.
describe_by(self, *args, **kwargs)	Descriptive summary statistics, excluding NaN values, along axes or for groups.
diff(self[, axis, d, n, label])	Calculates the n-th order discrete difference along a given axis.
divnot0(self, other)	Divides array by other, but returns 0.0 where other is 0.
drop(self[, labels])	Return array without some labels or indices along an axis.
drop_labels(*args, **kwargs)	
dump(self[, header, wide, value_name, . . .])	Dump array as a 2D nested list.
eq(self, other[, rtol, atol, nans_equal])	Compares self with another array element-wise and returns an array of booleans.
equals(self, other[, rtol, atol, . . .])	Compares self with another array and returns True if they have the same axes and elements, False otherwise.
expand(self[, target_axes, out, readonly])	Expands array to target_axes.
extend(self, axis, other)	Adds an array to self along an axis.
filter(self[, collapse])	Filters the array along the axes given as keyword arguments.
growth_rate(self[, axis, d, label])	Calculates the growth along a given axis.
ignore_labels(self[, axes])	Ignore labels from axes (replace those axes by "wildcard" axes).

Continued on next page

Table 28 – continued from previous page

indexofmax(self[, axis])	Returns indices of the maximum values along a given axis.
indexofmin(self[, axis])	Returns indices of the minimum values along a given axis.
indicesofsorted(self[, axis, ascending, kind])	Returns the indices that would sort this array.
insert(self, value[, before, after, pos, . . .])	Inserts value in array along an axis.
isin(self, test_values[, assume_unique, invert])	Computes whether each element of this array is in *test_values*.
items(self[, axes, ascending])	Returns a (label, value) view of the array along axes.
keys(self[, axes, ascending])	Returns a view on the array labels along axes.
labelofmax(self[, axis])	Returns labels of the maximum values along a given axis.
labelofmin(self[, axis])	Returns labels of the minimum values along a given axis.
labelsofsorted(self[, axis, ascending, kind])	Returns the labels that would sort this array.
max(*axes_and_groups[, out, skipna, keepaxes])	Get maximum of array elements along given axes/groups.
max_by(*axes_and_groups[, out, skipna, keepaxes])	Get maximum of array elements for the given axes/groups.
mean(*axes_and_groups[, dtype, out, skipna, . . .])	Computes the arithmetic mean.
mean_by(*axes_and_groups[, dtype, out, . . .])	Computes the arithmetic mean.
median(*axes_and_groups[, out, skipna, keepaxes])	Computes the arithmetic median.
median_by(*axes_and_groups[, out, skipna, . . .])	Computes the arithmetic median.
min(*axes_and_groups[, out, skipna, keepaxes])	Get minimum of array elements along given axes/groups.
min_by(*axes_and_groups[, out, skipna, keepaxes])	Get minimum of array elements for the given axes/groups.
nonzero(self)	Returns the indices of the elements that are non-zero.
percent(self, *axes)	Returns an array with values given as percent of the total of all values along given axes.
percentile(q, *axes_and_groups[, out, . . .])	Computes the qth percentile of the data along the specified axis.
percentile_by(q, *axes_and_groups[, out, . . .])	Computes the qth percentile of the data for the specified axis.
posargmax(*args, **kwargs)	
posargmin(*args, **kwargs)	
posargsort(*args, **kwargs)	
prepend(self, axis, value[, label])	Adds an array before self along an axis.
prod(*axes_and_groups[, dtype, out, skipna, . . .])	Computes the product of array elements along given axes/groups.
prod_by(*axes_and_groups[, dtype, out, . . .])	Computes the product of array elements for the given axes/groups.
ptp(*axes_and_groups[, out])	Returns the range of values (maximum - minimum).
ratio(self, *axes)	Returns an array with all values divided by the sum of values along given axes.
rationot0(self, *axes)	Returns a LArray with values array / array.sum(axes) where the sum is not 0, 0 otherwise.
reindex(self[, axes_to_reindex, new_axis, . . .])	Reorder and/or add new labels in axes.
rename(self[, renames, to, inplace])	Renames axes of the array.

Continued on next page

Table 28 – continued from previous page

reshape(self, target_axes)	Given a list of new axes, changes the shape of the array.
reshape_like(self, target)	Same as reshape but with an array as input.
reverse(self[, axes])	Reverse axes of an array
roll(self[, axis, n])	Rolls the cells of the array n-times to the right along axis.
set(self, value, **kwargs)	Sets a subset of array to value.
set_axes(self[, axes_to_replace, new_axis, . . .])	Replace one, several or all axes of the array.
set_labels(self[, axis, labels, inplace])	Replaces the labels of one or several axes of the array.
shift(self, axis[, n])	Shifts the cells of the array n-times to the right along axis.
sort_axes(self[, axes, ascending])	Sorts axes of the array.
sort_axis(*args, **kwargs)	
sort_values(self[, key, axis, ascending])	Sorts values of the array.
split_axes(self[, axes, sep, names, regex, . . .])	Split axes and returns a new array
split_axis(*args, **kwargs)	
std(*axes_and_groups[, dtype, ddof, out, . . .])	Computes the sample standard deviation.
std_by(*axes_and_groups[, dtype, ddof, out, . . .])	Computes the sample standard deviation.
sum(*axes_and_groups[, dtype, out, skipna, . . .])	Computes the sum of array elements along given axes/groups.
sum_by(*axes_and_groups[, dtype, out, . . .])	Computes the sum of array elements for the given axes/groups.
to_clipboard(self, *args, **kwargs)	Sends the content of the array to clipboard.
to_csv(self, filepath[, sep, na_rep, wide, . . .])	Writes array to a csv file.
to_excel(self[, filepath, sheet, position, . . .])	Writes array in the specified sheet of specified excel workbook.
to_frame(self[, fold_last_axis_name, dropna])	Converts LArray into Pandas DataFrame.
to_hdf(self, filepath, key)	Writes array to a HDF file.
to_series(self[, name, dropna])	Converts LArray into Pandas Series.
to_stata(self, filepath_or_buffer, **kwargs)	Writes array to a Stata .dta file.
transpose(self, *args)	Reorder axes.
unique(self[, axes, sort, sep])	Returns unique values (optionally along axes)
values(self[, axes, ascending])	Returns a view on the values of the array along axes.
var(*axes_and_groups[, dtype, ddof, out, . . .])	Computes the unbiased variance.
var_by(*axes_and_groups[, dtype, ddof, out, . . .])	Computes the unbiased variance.
with_axes(*args, **kwargs)	
with_total(*args[, op, label])	Add aggregated values (sum by default) along each axis.

Attributes

T	Reorder axes.
axes	
data	
df	Converts LArray into Pandas DataFrame.
dtype	Returns the type of the data of the array.
i	Allows selection of a subset using indices of labels.
iflat	Access the array by index as if it was flat (one dimensional) and all its axes were combined.

Continued on next page

Table 29 – continued from previous page

info	Describes a LArray (metadata + shape and labels for each axis).
ipoints	Allows selection of arbitrary items in the array based on their N-dimensional index.
item	
memory_used	Returns the memory consumed by the array in human readable form.
meta	Returns metadata of the array.
nbytes	Returns the number of bytes used to store the array in memory.
ndim	Returns the number of dimensions of the array.
plot	Plots the data of the array into a graph (window pop-up).
points	Allows selection of arbitrary items in the array based on their N-dimensional label index.
series	Converts LArray into Pandas Series.
shape	Returns the shape of the array as a tuple.
size	Returns the number of elements in array.
title	

Array Creation Functions

sequence(axis[, initial, inc, mult, func, . . .])	Creates an array by sequentially applying modifications to the array along axis.
ndtest(shape_or_axes[, start, label_start, . . .])	Returns test array with given shape.
zeros(axes[, title, dtype, order, meta])	Returns an array with the specified axes and filled with zeros.
zeros_like(array[, title, dtype, order, meta])	Returns an array with the same axes as array and filled with zeros.
ones(axes[, title, dtype, order, meta])	Returns an array with the specified axes and filled with ones.
ones_like(array[, title, dtype, order, meta])	Returns an array with the same axes as array and filled with ones.
empty(axes[, title, dtype, order, meta])	Returns an array with the specified axes and uninitialized (arbitrary) data.
empty_like(array[, title, dtype, order, meta])	Returns an array with the same axes as array and uninitialized (arbitrary) data.
full(axes, fill_value[, title, dtype, . . .])	Returns an array with the specified axes and filled with fill_value.
full_like(array, fill_value[, title, dtype, . . .])	Returns an array with the same axes and type as input array and filled with fill_value.

larray.sequence

larray.**sequence**(*axis*, *initial=0*, *inc=None*, *mult=1*, *func=None*, *axes=None*, *title=None*, *meta=None*)

Creates an array by sequentially applying modifications to the array along axis.

The value for each label in axis will be given by sequentially transforming the value for the previous label. This transformation on the previous label value consists of applying the function "func" on that value if provided, or to multiply it by mult and increment it by inc otherwise.

Parameters

axis [axis definition (Axis, str, int)] Axis along which to apply mod. An axis definition can be passed as a string. An int will be interpreted as the length for a new anonymous axis.

initial [scalar or LArray, optional] Value for the first label of axis. Defaults to 0.

inc [scalar, LArray, optional] Value to increment the previous value by. Defaults to 0 if mult is provided, 1 otherwise.

mult [scalar, LArray, optional] Value to multiply the previous value by. Defaults to 1.

func [function/callable, optional] Function to apply to the previous value. Defaults to None. Note that this is much slower than using inc and/or mult.

axes [int, tuple of int or tuple/list/AxisCollection of Axis, optional] Axes of the result. Defaults to the union of axes present in other arguments.

title [str, optional] Deprecated. See 'meta' below.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Examples

```
>>> year = Axis('year=2016..2019')
>>> sex = Axis('sex=M,F')
>>> sequence(year)
year  2016  2017  2018  2019
         0     1     2     3
>>> sequence('year=2016..2019')
year  2016  2017  2018  2019
         0     1     2     3
>>> sequence(year, 1.0, 0.5)
year  2016  2017  2018  2019
       1.0   1.5   2.0   2.5
>>> sequence(year, 1.0, mult=1.5)
year  2016  2017  2018   2019
       1.0   1.5  2.25  3.375
>>> inc = LArray([1, 2], [sex])
>>> inc
sex  M  F
     1  2
>>> sequence(year, 1.0, inc)
sex\year  2016  2017  2018  2019
       M   1.0   2.0   3.0   4.0
       F   1.0   3.0   5.0   7.0
>>> mult = LArray([2, 3], [sex])
>>> mult
sex  M  F
     2  3
>>> sequence(year, 1.0, mult=mult)
sex\year  2016  2017  2018  2019
       M   1.0   2.0   4.0   8.0
       F   1.0   3.0   9.0  27.0
>>> initial = LArray([3, 4], [sex])
>>> initial
sex  M  F
     3  4
>>> sequence(year, initial, 1)
```

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```
sex\year  2016  2017  2018  2019
       M     3     4     5     6
       F     4     5     6     7
>>> sequence(year, initial, mult=2)
sex\year  2016  2017  2018  2019
       M     3     6    12    24
       F     4     8    16    32
>>> sequence(year, initial, inc, mult)
sex\year  2016  2017  2018  2019
       M     3     7    15    31
       F     4    14    44   134
>>> def modify(prev_value):
...     return prev_value / 2
>>> sequence(year, 8, func=modify)
year  2016  2017  2018  2019
         8     4     2     1
>>> sequence(3)
{0}*  0  1  2
      0  1  2
>>> sequence('year', axes=(sex, year))
sex\year  2016  2017  2018  2019
       M     0     1     2     3
       F     0     1     2     3
```

sequence can be used as the inverse of growth_rate:

```
>>> a = LArray([1.0, 2.0, 3.0, 3.0], year)
>>> a
year  2016  2017  2018  2019
       1.0   2.0   3.0   3.0
>>> g = a.growth_rate() + 1
>>> g
year  2017  2018  2019
       2.0   1.5   1.0
>>> sequence(year, a[2016], mult=g)
year  2016  2017  2018  2019
       1.0   2.0   3.0   3.0
```

larray.ndtest

`larray.`**`ndtest`**(*shape_or_axes*, *start=0*, *label_start=0*, *title=None*, *dtype=<class 'int'>*, *meta=None*)

Returns test array with given shape.

Axes are named by single letters starting from 'a'. Axes labels are constructed using a '{axis_name}{label_pos}' pattern (e.g. 'a0'). Values start from *start* increase by steps of 1.

Parameters

shape_or_axes [int, tuple/list of int, str, single axis or tuple/list/AxisCollection of axes] If int or tuple/list of int, represents the shape of the array to create. In that case, default axes are generated. If string, it is used to generate axes (see `AxisCollection` constructor).

start [int or float, optional] Start value

label_start [int, optional] Label index for each axis is *label_start* + *position*. *label_start* defaults to 0.

title [str, optional] Deprecated. See 'meta' below.

dtype [type or np.dtype, optional] Type of resulting array.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, . . .) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

Create test array by passing a shape

```
>>> ndtest(6)
a   a0   a1   a2   a3   a4   a5
     0    1    2    3    4    5
>>> ndtest((2, 3))
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> ndtest((2, 3), label_start=1)
a\b  b1  b2  b3
 a1   0   1   2
 a2   3   4   5
>>> ndtest((2, 3), start=2)
a\b  b0  b1  b2
 a0   2   3   4
 a1   5   6   7
>>> ndtest((2, 3), dtype=float)
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  4.0  5.0
```

Create test array by passing axes

```
>>> ndtest("nat=BE,FO;sex=M,F")
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> nat = Axis("nat=BE,FO")
>>> sex = Axis("sex=M,F")
>>> ndtest([nat, sex])
nat\sex  M  F
     BE  0  1
     FO  2  3
```

larray.zeros

`larray.zeros` (*axes*, *title=None*, *dtype=<class 'float'>*, *order='C'*, *meta=None*)

Returns an array with the specified axes and filled with zeros.

Parameters

axes [int, tuple of int, Axis or tuple/list/AxisCollection of Axis] Collection of axes or a shape.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Desired data-type for the array, e.g., *numpy.int8*. Default is *numpy.float64*.

order [{'C', 'F'}, optional] Whether to store multidimensional data in C- (default) or Fortran-contiguous (row- or column-wise) order in memory.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, . . .) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> zeros('nat=BE,FO;sex=M,F')
nat\sex    M    F
     BE  0.0  0.0
     FO  0.0  0.0
>>> zeros([(['BE', 'FO'], 'nat'),
...         (['M', 'F'], 'sex')])
nat\sex    M    F
     BE  0.0  0.0
     FO  0.0  0.0
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> zeros([nat, sex])
nat\sex    M    F
     BE  0.0  0.0
     FO  0.0  0.0
```

larray.zeros_like

`larray.zeros_like`(*array*, *title=None*, *dtype=None*, *order='K'*, *meta=None*)

Returns an array with the same axes as array and filled with zeros.

Parameters

array [LArray] Input array.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Overrides the data type of the result.

order [{'C', 'F', 'A', or 'K'}, optional] Overrides the memory layout of the result. 'C' means C-order, 'F' means F-order, 'A' means 'F' if *a* is Fortran contiguous, 'C' otherwise. 'K' (default) means match the layout of *a* as closely as possible.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, . . .) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> a = ndtest((2, 3))
>>> zeros_like(a)
a\b  b0  b1  b2
 a0   0   0   0
 a1   0   0   0
```

larray.ones

larray.**ones**(*axes*, *title=None*, *dtype=<class 'float'>*, *order='C'*, *meta=None*)

Returns an array with the specified axes and filled with ones.

Parameters

axes [int, tuple of int, Axis or tuple/list/AxisCollection of Axis] Collection of axes or a shape.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Desired data-type for the array, e.g., *numpy.int8*. Default is *numpy.float64*.

order [{'C', 'F'}, optional] Whether to store multidimensional data in C- (default) or Fortran-contiguous (row- or column-wise) order in memory.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> ones([nat, sex])
nat\sex    M    F
     BE  1.0  1.0
     FO  1.0  1.0
```

larray.ones_like

larray.**ones_like**(*array*, *title=None*, *dtype=None*, *order='K'*, *meta=None*)

Returns an array with the same axes as array and filled with ones.

Parameters

array [LArray] Input array.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Overrides the data type of the result.

order [{'C', 'F', 'A', or 'K'}, optional] Overrides the memory layout of the result. 'C' means C-order, 'F' means F-order, 'A' means 'F' if *a* is Fortran contiguous, 'C' otherwise. 'K' (default) means match the layout of *a* as closely as possible.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> a = ndtest((2, 3))
>>> ones_like(a)
a\b  b0  b1  b2
 a0   1   1   1
 a1   1   1   1
```

larray.empty

`larray.empty`(*axes*, *title=None*, *dtype=<class 'float'>*, *order='C'*, *meta=None*)

Returns an array with the specified axes and uninitialized (arbitrary) data.

Parameters

axes [int, tuple of int, Axis or tuple/list/AxisCollection of Axis] Collection of axes or a shape.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Desired data-type for the array, e.g., *numpy.int8*. Default is *numpy.float64*.

order [{'C', 'F'}, optional] Whether to store multidimensional data in C- (default) or Fortran-contiguous (row- or column-wise) order in memory.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> empty([nat, sex])  # doctest: +SKIP
nat\sex                  M                    F
     BE  2.47311483356e-315  2.47498446195e-315
     FO                 0.0   6.07684618082e-31
```

larray.empty_like

`larray.empty_like(array, title=None, dtype=None, order='K', meta=None)`

Returns an array with the same axes as array and uninitialized (arbitrary) data.

Parameters

array [LArray] Input array.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Overrides the data type of the result. Defaults to the data type of array.

order [{'C', 'F', 'A', or 'K'}, optional] Overrides the memory layout of the result. 'C' means C-order, 'F' means F-order, 'A' means 'F' if *a* is Fortran contiguous, 'C' otherwise. 'K' (default) means match the layout of *a* as closely as possible.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> a = ndtest((3, 2))
>>> empty_like(a)   # doctest: +SKIP
a\b                   b0                   b1
 a0  2.12199579097e-314  6.36598737388e-314
 a1  1.06099789568e-313  1.48539705397e-313
 a2  1.90979621226e-313  2.33419537056e-313
```

larray.full

`larray.full(axes, fill_value, title=None, dtype=None, order='C', meta=None)`

Returns an array with the specified axes and filled with fill_value.

Parameters

axes [int, tuple of int, Axis or tuple/list/AxisCollection of Axis] Collection of axes or a shape.

fill_value [scalar or LArray] Value to fill the array

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Desired data-type for the array. Default is the data type of fill_value.

order [{'C', 'F'}, optional] Whether to store multidimensional data in C- (default) or Fortran-contiguous (row- or column-wise) order in memory.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> full([nat, sex], 42.0)
nat\sex     M     F
     BE  42.0  42.0
     FO  42.0  42.0
>>> initial_value = ndtest([sex])
>>> initial_value
sex  M  F
     0  1
>>> full([nat, sex], initial_value)
nat\sex  M  F
     BE  0  1
     FO  0  1
```

larray.full_like

larray.**full_like**(*array*, *fill_value*, *title=None*, *dtype=None*, *order='K'*, *meta=None*)

Returns an array with the same axes and type as input array and filled with fill_value.

Parameters

array [LArray] Input array.

fill_value [scalar or LArray] Value to fill the array

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Overrides the data type of the result. Defaults to the data type of array.

order [{'C', 'F', 'A', or 'K'}, optional] Overrides the memory layout of the result. 'C' means C-order, 'F' means F-order, 'A' means 'F' if *a* is Fortran contiguous, 'C' otherwise. 'K' (default) means match the layout of *a* as closely as possible.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> a = ndtest((2, 3))
>>> full_like(a, 5)
a\b  b0  b1  b2
 a0   5   5   5
 a1   5   5   5
```

Copying

LArray.copy(self)	Returns a copy of the array.
LArray.astype(dtype[, order, casting, ...])	Copy of the array, cast to a specified type.

larray.LArray.copy

`LArray.`**`copy`**(*self*)

Returns a copy of the array.

larray.LArray.astype

`LArray.`**`astype`**(*dtype*, *order='K'*, *casting='unsafe'*, *subok=True*, *copy=True*)

Copy of the array, cast to a specified type.

Parameters

dtype [str or dtype] Typecode or data-type to which the array is cast.

order [{'C', 'F', 'A', 'K'}, optional] Controls the memory layout order of the result. 'C' means C order, 'F' means Fortran order, 'A' means 'F' order if all the arrays are Fortran contiguous, 'C' order otherwise, and 'K' means as close to the order the array elements appear in memory as possible. Default is 'K'.

casting [{'no', 'equiv', 'safe', 'same_kind', 'unsafe'}, optional] Controls what kind of data casting may occur. Defaults to 'unsafe' for backwards compatibility.

- 'no' means the data types should not be cast at all.
- 'equiv' means only byte-order changes are allowed.
- 'safe' means only casts which can preserve values are allowed.
- 'same_kind' means only safe casts or casts within a kind, like float64 to float32, are allowed.
- 'unsafe' means any data conversions may be done.

subok [bool, optional] If True, then sub-classes will be passed-through (default), otherwise the returned array will be forced to be a base-class array.

copy [bool, optional] By default, astype always returns a newly allocated array. If this is set to false, and the *dtype*, *order*, and *subok* requirements are satisfied, the input array is returned instead of a copy.

Returns

arr_t [ndarray] Unless *copy* is False and the other conditions for returning the input array are satisfied (see description for *copy* input parameter), *arr_t* is a new array of the same shape as the input array, with dtype, order given by *dtype*, *order*.

Raises

ComplexWarning When casting from complex to float or int. To avoid this, one should use `a.real.astype(t)`.

Notes

Changed in version 1.17.0: Casting between a simple data type and a structured one is possible only for "unsafe" casting. Casting to multiple fields is allowed, but casting from multiple fields is not.

Changed in version 1.9.0: Casting from numeric to string types in 'safe' casting mode requires that the string dtype length is long enough to store the max integer/float value converted.

Examples

```
>>> x = np.array([1, 2, 2.5])
>>> x
array([1. ,  2. ,  2.5])
```

```
>>> x.astype(int)
array([1, 2, 2])
```

Inspecting

LArray.data	Data of the array (Numpy ndarray)
LArray.axes	Axes of the array (AxisCollection)
LArray.title	Title of the array (str)

LArray.info	Describes a LArray (metadata + shape and labels for each axis).
LArray.shape	Returns the shape of the array as a tuple.
LArray.ndim	Returns the number of dimensions of the array.
LArray.dtype	Returns the type of the data of the array.
LArray.size	Returns the number of elements in array.
LArray.nbytes	Returns the number of bytes used to store the array in memory.
LArray.memory_used	Returns the memory consumed by the array in human readable form.

larray.LArray.info

property LArray.**info**

Describes a LArray (metadata + shape and labels for each axis).

Returns

str Description of the array (metadata + shape and labels for each axis).

Examples

```
>>> mat0 = LArray([[2.0, 5.0], [8.0, 6.0]], "nat=BE,FO; sex=F,M")
>>> mat0.info
2 x 2
 nat [2]: 'BE' 'FO'
 sex [2]: 'F' 'M'
dtype: float64
memory used: 32 bytes
>>> mat0.meta.title = 'test matrix'
```

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```
>>> mat0.info
title: test matrix
2 x 2
 nat [2]: 'BE' 'FO'
 sex [2]: 'F' 'M'
dtype: float64
memory used: 32 bytes
```

larray.LArray.shape

property LArray.**shape**

Returns the shape of the array as a tuple.

Returns

tuple Tuple representing the current shape.

Examples

```
>>> a = ndtest('nat=BE,FO;sex=M,F;type=type1,type2,type3')
>>> a.shape  # doctest: +SKIP
(2, 2, 3)
```

larray.LArray.ndim

property LArray.**ndim**

Returns the number of dimensions of the array.

Returns

int Number of dimensions of a LArray.

Examples

```
>>> a = ndtest('nat=BE,FO;sex=M,F')
>>> a.ndim
2
```

larray.LArray.dtype

property LArray.**dtype**

Returns the type of the data of the array.

Returns

dtype Type of the data of the array.

Examples

```
>>> a = zeros('sex=M,F;type=type1,type2,type3')
>>> a.dtype
dtype('float64')
```

larray.LArray.size

property LArray.**size**

Returns the number of elements in array.

Returns

int Number of elements in array.

Examples

```
>>> a = ndtest('sex=M,F;type=type1,type2,type3')
>>> a.size
6
```

larray.LArray.nbytes

property LArray.**nbytes**

Returns the number of bytes used to store the array in memory.

Returns

int Number of bytes in array.

Examples

```
>>> a = ndtest('sex=M,F;type=type1,type2,type3', dtype=float)
>>> a.nbytes
48
```

larray.LArray.memory_used

property LArray.**memory_used**

Returns the memory consumed by the array in human readable form.

Returns

str Memory used by the array.

Examples

```
>>> a = ndtest('sex=M,F;type=type1,type2,type3', dtype=float)
>>> a.memory_used
'48 bytes'
```

Modifying/Selecting

LArray.i	Allows selection of a subset using indices of labels.
LArray.points	Allows selection of arbitrary items in the array based on their N-dimensional label index.
LArray.ipoints	Allows selection of arbitrary items in the array based on their N-dimensional index.
LArray.iflat	Access the array by index as if it was flat (one dimensional) and all its axes were combined.
LArray.set(self, value, **kwargs)	Sets a subset of array to value.
LArray.drop(self[, labels])	Return array without some labels or indices along an axis.
LArray.ignore_labels(self[, axes])	Ignore labels from axes (replace those axes by "wildcard" axes).
LArray.filter(self[, collapse])	Filters the array along the axes given as keyword arguments.
LArray.apply(self, transform, *args, **kwargs)	Apply a transformation function to array elements.
LArray.apply_map(self, mapping[, dtype])	Apply a transformation mapping to array elements.

larray.LArray.i

LArray.**i**

Allows selection of a subset using indices of labels.

Examples

```
>>> arr = ndtest((2, 3, 4))
>>> arr
 a  b\c  c0  c1  c2  c3
a0   b0   0   1   2   3
a0   b1   4   5   6   7
a0   b2   8   9  10  11
a1   b0  12  13  14  15
a1   b1  16  17  18  19
a1   b2  20  21  22  23
```

```
>>> arr.i[:, 0:2, [0, 2]]
 a  b\c  c0  c2
a0   b0   0   2
a0   b1   4   6
a1   b0  12  14
a1   b1  16  18
```

larray.LArray.points

LArray.**points**

Allows selection of arbitrary items in the array based on their N-dimensional label index.

Examples

```
>>> arr = ndtest((2, 3, 4))
>>> arr
 a  b\c  c0  c1  c2  c3
a0   b0   0   1   2   3
a0   b1   4   5   6   7
a0   b2   8   9  10  11
a1   b0  12  13  14  15
a1   b1  16  17  18  19
a1   b2  20  21  22  23
```

To select the two points with label coordinates [a0, b0, c0] and [a1, b2, c2], you must do:

```
>>> arr.points['a0,a1', 'b0,b2', 'c0,c2']
a_b_c  a0_b0_c0  a1_b2_c2
              0        22
```

The number of label(s) on each dimension must be equal:

```
>>> arr.points['a0,a1', 'b0,b2', 'c0,c1,c2'] # doctest: +NORMALIZE_WHITESPACE
Traceback (most recent call last):
    ...
IndexError: shape mismatch: indexing arrays could not be broadcast together with
↪shapes (2,) (2,) (3,)
```

larray.LArray.ipoints

`LArray.ipoints`

Allows selection of arbitrary items in the array based on their N-dimensional index.

Examples

```
>>> arr = ndtest((2, 3, 4))
>>> arr
 a  b\c  c0  c1  c2  c3
a0   b0   0   1   2   3
a0   b1   4   5   6   7
a0   b2   8   9  10  11
a1   b0  12  13  14  15
a1   b1  16  17  18  19
a1   b2  20  21  22  23
```

To select the two points with index coordinates [0, 0, 0] and [1, 2, 2], you must do:

```
>>> arr.ipoints[[0,1], [0,2], [0,2]]
a_b_c  a0_b0_c0  a1_b2_c2
              0        22
```

The number of index(es) on each dimension must be equal:

```
>>> arr.ipoints[[0,1], [0,2], [0,1,2]] # doctest: +NORMALIZE_WHITESPACE
Traceback (most recent call last):
```

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```
    ...
IndexError: shape mismatch: indexing arrays could not be broadcast together with␣
↪shapes (2,) (2,) (3,)
```

larray.LArray.iflat

`LArray.iflat`

Access the array by index as if it was flat (one dimensional) and all its axes were combined.

Notes

In general arr.iflat[key] should be equivalent to (but much faster than) arr.combine_axes().i[key]

Examples

```
>>> arr = ndtest((2, 3)) * 10
>>> arr
a\b  b0  b1  b2
 a0   0  10  20
 a1  30  40  50
```

To select the first, second, fourth and fifth values across all axes:

```
>>> arr.combine_axes().i[[0, 1, 3, 4]]
a_b  a0_b0  a0_b1  a1_b0  a1_b1
         0     10     30     40
>>> arr.iflat[[0, 1, 3, 4]]
a_b  a0_b0  a0_b1  a1_b0  a1_b1
         0     10     30     40
```

Set the first and sixth values to 42

```
>>> arr.iflat[[0, 5]] = 42
>>> arr
a\b  b0  b1  b2
 a0  42  10  20
 a1  30  40  42
```

When the key is an LArray, the result will have the axes of the key

```
>>> key = LArray([0, 3], 'c=c0,c1')
>>> key
c  c0  c1
    0   3
>>> arr.iflat[key]
c  c0  c1
   42  30
```

larray.LArray.set

`LArray.set(self, value, **kwargs)`
Sets a subset of array to value.

- all common axes must be either of length 1 or the same length
- extra axes in value must be of length 1
- extra axes in current array can have any length

Parameters

value [scalar or LArray]

Examples

```
>>> arr = ndtest((3, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
 a2   6   7   8
>>> arr['a1:', 'b1:'].set(10)
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3  10  10
 a2   6  10  10
>>> arr['a1:', 'b1:'].set(ndtest("a=a1,a2;b=b1,b2"))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   0   1
 a2   6   2   3
```

larray.LArray.drop

`LArray.drop(self, labels=None)`
Return array without some labels or indices along an axis.

Parameters

labels [scalar, list or Group] Label(s) or group to remove. To remove indices, one must pass an IGroup.

Returns

LArray Array with *labels* removed along their axis.

Examples

```
>>> arr1 = ndtest((2, 4))
>>> arr1
a\b  b0  b1  b2  b3
```

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```
 a0   0   1   2   3
 a1   4   5   6   7
>>> a, b = arr1.axes
```

dropping a single label

```
>>> arr1.drop('b1')
a\b  b0  b2  b3
 a0   0   2   3
 a1   4   6   7
```

dropping multiple labels

```
>>> # arr1.drop('b1,b3')
>>> arr1.drop(['b1', 'b3'])
a\b  b0  b2
 a0   0   2
 a1   4   6
```

dropping a slice

```
>>> # arr1.drop('b1:b3')
>>> arr1.drop(b['b1':'b3'])
a\b  b0
 a0   0
 a1   4
```

when deleting indices instead of labels, one must specify the axis explicitly (using an IGroup):

```
>>> # arr1.drop('b.i[1]')
>>> arr1.drop(b.i[1])
a\b  b0  b2  b3
 a0   0   2   3
 a1   4   6   7
```

as when deleting ambiguous labels (which are present on several axes):

```
>>> a = Axis('a=label0..label2')
>>> b = Axis('b=label0..label2')
>>> arr2 = ndtest((a, b))
>>> arr2
   a\b  label0  label1  label2
label0       0       1       2
label1       3       4       5
label2       6       7       8
>>> # arr2.drop('a[label1]')
>>> arr2.drop(a['label1'])
   a\b  label0  label1  label2
label0       0       1       2
label2       6       7       8
```

larray.LArray.ignore_labels

`LArray.ignore_labels`(*self*, *axes=None*)

Ignore labels from axes (replace those axes by "wildcard" axes).

Useful when you want to apply operations between two arrays or subarrays with same shape but incompatible axes (different labels).

Parameters

axes [Axis or list/tuple/AxisCollection of Axis, optional] Axis(es) on which you want to drop the labels.

Returns

LArray

Notes

Use it at your own risk.

Examples

```
>>> a = Axis('a=a1,a2')
>>> b = Axis('b=b1,b2')
>>> b2 = Axis('b=b2,b3')
>>> arr1 = ndtest([a, b])
>>> arr1
a\b  b1  b2
 a1   0   1
 a2   2   3
>>> arr1.ignore_labels(b)
a\b*  0  1
  a1  0  1
  a2  2  3
>>> arr1.ignore_labels([a, b])
a*\b*  0  1
    0  0  1
    1  2  3
>>> arr2 = ndtest([a, b2])
>>> arr2
a\b  b2  b3
 a1   0   1
 a2   2   3
>>> arr1 * arr2
Traceback (most recent call last):
...
ValueError: incompatible axes:
Axis(['b2', 'b3'], 'b')
vs
Axis(['b1', 'b2'], 'b')
>>> arr1 * arr2.ignore_labels()
a\b  b1  b2
 a1   0   1
 a2   4   9
>>> arr1.ignore_labels() * arr2
a\b  b2  b3
 a1   0   1
 a2   4   9
>>> arr1.ignore_labels('a') * arr2.ignore_labels('b')
a\b  b1  b2
```

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```
a1    0    1
a2    4    9
```

larray.LArray.filter

`LArray.filter(self, collapse=False, **kwargs)`

Filters the array along the axes given as keyword arguments.

The *collapse* argument determines whether consecutive ranges should be collapsed to slices, which is more efficient and returns a view (and not a copy) if possible (if all ranges are consecutive). Only use this argument if you do not intent to modify the resulting array, or if you know what you are doing.

It is similar to np.take but works with several axes at once.

larray.LArray.apply

`LArray.apply(self, transform, *args, **kwargs)`

Apply a transformation function to array elements.

Parameters

transform [function] Function to apply. This function will be called in turn with each element of the array as the first argument and must return an LArray, scalar or tuple. If returning arrays the axes of those arrays must be the same for all calls to the function.

***args** Extra arguments to pass to the function.

by [str, int or Axis or tuple/list/AxisCollection of the them, optional] Axis or axes along which to iterate. The function will thus be called with arrays having all axes not mentioned. Defaults to None (all axes). Mutually exclusive with the *axes* argument.

axes [str, int or Axis or tuple/list/AxisCollection of the them, optional] Axis or axes the arrays passed to the function will have. Defaults to None (the function is given scalars). Mutually exclusive with the *by* argument.

dtype [type or list of types, optional] Output(s) data type(s). Defaults to None (inspect all output values to infer it automatically).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

****kwargs** Extra keyword arguments are passed to the function (as keyword arguments).

Returns

LArray or scalar, or tuple of them Axes will be the union of those in axis and those of values returned by the function.

Examples

First let us define a test array

```
>>> arr = LArray([[0, 2, 1],
...               [3, 1, 5]], 'a=a0,a1;b=b0..b2')
>>> arr
```

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```
a\b  b0  b1  b2
 a0   0   2   1
 a1   3   1   5
```

Here is a simple function we would like to apply to each element of the array. Note that this particular example should rather be written as: arr ** 2 as it is both more concise and much faster.

```
>>> def square(x):
...     return x ** 2
>>> arr.apply(square)
a\b  b0  b1  b2
 a0   0   4   1
 a1   9   1  25
```

Functions can also be applied along some axes:

```
>>> # this is equivalent to (but much slower than): arr.sum('a')
... arr.apply(sum, axes='a')
b  b0  b1  b2
    3   3   6
>>> # this is equivalent to (but much slower than): arr.sum_by('a')
... arr.apply(sum, by='a')
a  a0  a1
    3   9
```

Applying the function along some axes will return an array with the union of those axes and the axes of the returned values. For example, let us define a function which returns the k highest values of an array.

```
>>> def topk(a, k=2):
...     return a.sort_values(ascending=False).ignore_labels().i[:k]
>>> arr.apply(topk, by='a')
a\b*  0  1
  a0  2  1
  a1  5  3
```

Other arguments can be passed to the function:

```
>>> arr.apply(topk, 3, by='a')
a\b*  0  1  2
  a0  2  1  0
  a1  5  3  1
```

or by using keyword arguments:

```
>>> arr.apply(topk, by='a', k=3)
a\b*  0  1  2
  a0  2  1  0
  a1  5  3  1
```

If the function returns several values (as a tuple), the result will be a tuple of arrays. For example, let use define a function which decompose an array in its mean and the difference to that mean :

```
>>> def mean_decompose(a):
...     mean = a.mean()
...     return mean, a - mean
>>> mean_by_a, diff_to_mean = arr.apply(mean_decompose, by='a')
```

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```
>>> mean_by_a
a    a0    a1
   1.0   3.0
>>> diff_to_mean
a\b     b0     b1    b2
 a0   -1.0    1.0   0.0
 a1    0.0   -2.0   2.0
```

larray.LArray.apply_map

LArray.**apply_map**(*self*, *mapping*, *dtype=None*)

Apply a transformation mapping to array elements.

Parameters

mapping [mapping (dict)] Mapping to apply to values of the array. A mapping (dict) must have the values to transform as keys and the new values as values, that is: {<oldvalue1>: <newvalue1>, <oldvalue2>: <newvalue2>, . . . }.

dtype [type, optional] Output dtype. Defaults to None (inspect all output values to infer it automatically).

Returns

LArray Axes will be the same as the original array axes.

Notes

To apply a transformation given as an LArray (with current values as labels on one axis of the array and desired values as the array values), you can use: `mapping_arr[original_arr]`.

Examples

First let us define a test array

```
>>> arr = LArray([[0, 2, 1],
...               [3, 1, 5]], 'a=a0,a1;b=b0..b2')
>>> arr
a\b  b0  b1  b2
 a0   0   2   1
 a1   3   1   5
```

Now, assuming for a moment that the values of our test array above were in fact some numeric representation of names and we had the correspondence to the actual names stored in a dictionary:

```
>>> code_to_names = {0: 'foo', 1: 'bar', 2: 'baz',
...                  3: 'boo', 4: 'far', 5: 'faz'}
```

We could get back an array with the actual names by using:

```
>>> arr.apply_map(code_to_names)
a\b   b0   b1   b2
 a0  foo  baz  bar
 a1  boo  bar  faz
```

Changing Axes or Labels

LArray.set_axes(self[, axes_to_replace, ...])	Replace one, several or all axes of the array.
LArray.rename(self[, renames, to, inplace])	Renames axes of the array.
LArray.set_labels(self[, axis, labels, inplace])	Replaces the labels of one or several axes of the array.
LArray.combine_axes(self[, axes, sep, wildcard])	Combine several axes into one.
LArray.split_axes(self[, axes, sep, names, ...])	Split axes and returns a new array
LArray.reverse(self[, axes])	Reverse axes of an array

larray.LArray.set_axes

LArray.**set_axes**(*self*, *axes_to_replace=None*, *new_axis=None*, *inplace=False*, ***kwargs*)
Replace one, several or all axes of the array.

Parameters

axes_to_replace [axis ref or dict {axis ref: axis} or list of tuple (axis ref, axis)]

or list of Axis or AxisCollection

Axes to replace. If a single axis reference is given, the *new_axis* argument must be provided. If a list of Axis or an AxisCollection is given, all axes will be replaced by the new ones. In that case, the number of new axes must match the number of old ones.

new_axis [Axis, optional] New axis if *axes_to_replace* contains a single axis reference.

inplace [bool, optional] Whether or not to modify the original object or return a new array and leave the original intact. Defaults to False.

****kwargs** [Axis] New axis for each axis to replace given as a keyword argument.

Returns

LArray Array with axes replaced.

See also:

rename rename one of several axes

Examples

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> row = Axis(['r0', 'r1'], 'row')
>>> column = Axis(['c0', 'c1', 'c2'], 'column')
```

Replace one axis (second argument *new_axis* must be provided)

```
>>> arr.set_axes('a', row)
row\b  b0  b1  b2
   r0   0   1   2
   r1   3   4   5
```

Replace several axes (keywords, list of tuple or dictionary)

```
>>> arr.set_axes(a=row, b=column) # doctest: +SKIP
>>> # or
>>> arr.set_axes([('a', row), ('b', column)]) # doctest: +SKIP
>>> # or
>>> arr.set_axes({'a': row, 'b': column})
row\column  c0  c1  c2
        r0   0   1   2
        r1   3   4   5
```

Replace all axes (list of axes or AxisCollection)

```
>>> arr.set_axes([row, column])
row\column  c0  c1  c2
        r0   0   1   2
        r1   3   4   5
>>> arr2 = ndtest([row, column])
>>> arr.set_axes(arr2.axes)
row\column  c0  c1  c2
        r0   0   1   2
        r1   3   4   5
```

larray.LArray.rename

LArray.**rename**(*self*, *renames=None*, *to=None*, *inplace=False*, ***kwargs*)
Renames axes of the array.

Parameters

renames [axis ref or dict {axis ref: str} or list of tuple (axis ref, str)] Renames to apply. If a single axis reference is given, the *to* argument must be used.

to [str or Axis] New name if *renames* contains a single axis reference.

****kwargs** [str or Axis] New name for each axis given as a keyword argument.

Returns

LArray Array with axes renamed.

See also:

set_axes replace one or several axes

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> arr = ndtest([nat, sex])
>>> arr
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> arr.rename(nat, 'nat2')
nat2\sex  M  F
      BE  0  1
      FO  2  3
```

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```
>>> arr.rename(nat='nat2', sex='sex2')
nat2\sex2  M  F
       BE  0  1
       FO  2  3
>>> arr.rename([('nat', 'nat2'), ('sex', 'sex2')])
nat2\sex2  M  F
       BE  0  1
       FO  2  3
>>> arr.rename({'nat': 'nat2', 'sex': 'sex2'})
nat2\sex2  M  F
       BE  0  1
       FO  2  3
```

larray.LArray.set_labels

LArray.**set_labels**(*self*, *axis=None*, *labels=None*, *inplace=False*, ***kwargs*)

Replaces the labels of one or several axes of the array.

Parameters

axis [string or Axis or dict] Axis for which we want to replace labels, or mapping {axis: changes} where changes can either be the complete list of labels, a mapping {old_label: new_label} or a function to transform labels. If there is no ambiguity (two or more axes have the same labels), *axis* can be a direct mapping {old_label: new_label}.

labels [int, str, iterable or mapping or function, optional] Integer or list of values usable as the collection of labels for an Axis. If this is mapping, it must be {old_label: new_label}. If it is a function, it must be a function accepting a single argument (a label) and returning a single value. This argument must not be used if axis is a mapping.

inplace [bool, optional] Whether or not to modify the original object or return a new array and leave the original intact. Defaults to False.

****kwargs :** *axis*'='*labels* for each axis you want to set labels.

Returns

LArray Array with modified labels.

See also:

`AxisCollection.set_labels`

Examples

```
>>> a = ndtest('nat=BE,FO;sex=M,F')
>>> a
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> a.set_labels('sex', ['Men', 'Women'])
nat\sex  Men  Women
     BE    0      1
     FO    2      3
```

when passing a single string as labels, it will be interpreted to create the list of labels, so that one can use the same syntax than during axis creation.

```
>>> a.set_labels('sex', 'Men,Women')
nat\sex  Men  Women
     BE    0      1
     FO    2      3
```

to replace only some labels, one must give a mapping giving the new label for each label to replace

```
>>> a.set_labels('sex', {'M': 'Men'})
nat\sex  Men  F
     BE    0  1
     FO    2  3
```

to transform labels by a function, use any function accepting and returning a single argument:

```
>>> a.set_labels('nat', str.lower)
nat\sex  M  F
     be  0  1
     fo  2  3
```

to replace labels for several axes at the same time, one should give a mapping giving the new labels for each changed axis

```
>>> a.set_labels({'sex': 'Men,Women', 'nat': 'Belgian,Foreigner'})
  nat\sex  Men  Women
  Belgian    0      1
Foreigner    2      3
```

or use keyword arguments

```
>>> a.set_labels(sex='Men,Women', nat='Belgian,Foreigner')
  nat\sex  Men  Women
  Belgian    0      1
Foreigner    2      3
```

one can also replace some labels in several axes by giving a mapping of mappings

```
>>> a.set_labels({'sex': {'M': 'Men'}, 'nat': {'BE': 'Belgian'}})
nat\sex  Men  F
Belgian    0  1
     FO    2  3
```

when there is no ambiguity (two or more axes have the same labels), it is possible to give a mapping between old and new labels

```
>>> a.set_labels({'M': 'Men', 'BE': 'Belgian'})
nat\sex  Men  F
Belgian    0  1
     FO    2  3
```

larray.LArray.combine_axes

LArray.**combine_axes**(*self*, *axes=None*, *sep='_'*, *wildcard=False*)

Combine several axes into one.

Parameters

axes [tuple, list, AxisCollection of axes or list of combination of those or dict, optional] axes to combine. Tuple, list or AxisCollection will combine several axes into one. To chain several axes combinations, pass a list of tuple/list/AxisCollection of axes. To set the name(s) of resulting axis(es), use a {(axes, to, combine): 'new_axis_name'} dictionary. Defaults to all axes.

sep [str, optional] delimiter to use for combining. Defaults to '_'.

wildcard [bool, optional] whether or not to produce a wildcard axis even if the axes to combine are not. This is much faster, but loose axes labels.

Returns

LArray Array with combined axes.

Examples

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> arr.combine_axes()
a_b  a0_b0  a0_b1  a0_b2  a1_b0  a1_b1  a1_b2
         0      1      2      3      4      5
>>> arr.combine_axes(sep='/')
a/b  a0/b0  a0/b1  a0/b2  a1/b0  a1/b1  a1/b2
         0      1      2      3      4      5
>>> arr = ndtest((2, 2, 2, 2))
>>> arr
 a   b  c\d  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
>>> arr.combine_axes(('a', 'c'))
  a_c  b\d  d0  d1
a0_c0   b0   0   1
a0_c0   b1   4   5
a0_c1   b0   2   3
a0_c1   b1   6   7
a1_c0   b0   8   9
a1_c0   b1  12  13
a1_c1   b0  10  11
a1_c1   b1  14  15
>>> arr.combine_axes({('a', 'c'): 'ac'})
   ac  b\d  d0  d1
a0_c0   b0   0   1
a0_c0   b1   4   5
a0_c1   b0   2   3
a0_c1   b1   6   7
a1_c0   b0   8   9
```

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```
a1_c0   b1  12  13
a1_c1   b0  10  11
a1_c1   b1  14  15
```

make several combinations at once

```
>>> arr.combine_axes([('a', 'c'), ('b', 'd')])
a_c\b_d  b0_d0  b0_d1  b1_d0  b1_d1
  a0_c0      0      1      4      5
  a0_c1      2      3      6      7
  a1_c0      8      9     12     13
  a1_c1     10     11     14     15
>>> arr.combine_axes({('a', 'c'): 'ac', ('b', 'd'): 'bd'})
ac\bd  b0_d0  b0_d1  b1_d0  b1_d1
a0_c0      0      1      4      5
a0_c1      2      3      6      7
a1_c0      8      9     12     13
a1_c1     10     11     14     15
```

larray.LArray.split_axes

LArray.**split_axes**(*self*, *axes=None*, *sep='_'*, *names=None*, *regex=None*, *sort=False*, *fill_value=nan*)

Split axes and returns a new array

Parameters

axes [int, str, Axis or any combination of those] axes to split. All labels *must* contain the given delimiter string. To split several axes at once, pass a list or tuple of axes to split. To set the names of resulting axes, use a {'axis_to_split': (new, axes)} dictionary. Defaults to all axes whose name contains the *sep* delimiter.

sep [str, optional] delimiter to use for splitting. Defaults to '_'. When *regex* is provided, the delimiter is only used on *names* if given as one string or on axis name if *names* is None.

names [str or list of str, optional] names of resulting axes. Defaults to None.

regex [str, optional] use regex instead of delimiter to split labels. Defaults to None.

sort [bool, optional] Whether or not to sort the combined axis before splitting it. When all combinations of labels are present in the combined axis, sorting is faster than not sorting. Defaults to False.

fill_value [scalar or LArray, optional] Value to use for missing values when the combined axis does not contain all combination of labels. Defaults to NaN.

Returns

LArray

Examples

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
```

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```
>>> combined = arr.combine_axes()
>>> combined
a_b  a0_b0  a0_b1  a0_b2  a1_b0  a1_b1  a1_b2
         0      1      2      3      4      5
>>> combined.split_axes()
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
```

Split labels using regex

```
>>> combined = ndtest('a_b=a0b0..a1b2')
>>> combined
a_b  a0b0  a0b1  a0b2  a1b0  a1b1  a1b2
        0     1     2     3     4     5
>>> combined.split_axes('a_b', regex=r'(\w{2})(\w{2})')
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
```

Split several axes at once

```
>>> combined = ndtest('a_b=a0_b0..a1_b1; c_d=c0_d0..c1_d1')
>>> combined
a_b\c_d  c0_d0  c0_d1  c1_d0  c1_d1
  a0_b0      0      1      2      3
  a0_b1      4      5      6      7
  a1_b0      8      9     10     11
  a1_b1     12     13     14     15
>>> # equivalent to combined.split_axes() which split all axes whose name
↪contains the `sep` delimiter.
>>> combined.split_axes(['a_b', 'c_d'])
 a   b  c\d  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
>>> combined.split_axes({'a_b': ('A', 'B'), 'c_d': ('C', 'D')})
 A   B  C\D  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
```

larray.LArray.reverse

`LArray.reverse(self, axes=None)`
Reverse axes of an array

Parameters

axes [int, str, Axis or any combination of those] axes to reverse. If None, all axes are reversed. Defaults to None.

Returns

LArray Array with passed *axes* reversed.

Examples

```
>>> arr = ndtest((2, 2, 2))
>>> arr
 a  b\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
```

Reverse one axis

```
>>> arr.reverse('c')
 a  b\c  c1  c0
a0   b0   1   0
a0   b1   3   2
a1   b0   5   4
a1   b1   7   6
```

Reverse several axes

```
>>> arr.reverse(('a', 'c'))
 a  b\c  c1  c0
a1   b0   5   4
a1   b1   7   6
a0   b0   1   0
a0   b1   3   2
```

Reverse all axes

```
>>> arr.reverse()
 a  b\c  c1  c0
a1   b1   7   6
a1   b0   5   4
a0   b1   3   2
a0   b0   1   0
```

Aggregation Functions

LArray.sum(*axes_and_groups[, dtype, out, . . .])	Computes the sum of array elements along given axes/groups.
LArray.sum_by(*axes_and_groups[, dtype, . . .])	Computes the sum of array elements for the given axes/groups.
LArray.prod(*axes_and_groups[, dtype, out, . . .])	Computes the product of array elements along given axes/groups.
LArray.prod_by(*axes_and_groups[, dtype, . . .])	Computes the product of array elements for the given axes/groups.
LArray.cumsum(self[, axis])	Returns the cumulative sum of array elements along an axis.
LArray.cumprod(self[, axis])	Returns the cumulative product of array elements.
LArray.mean(*axes_and_groups[, dtype, out, . . .])	Computes the arithmetic mean.
LArray.mean_by(*axes_and_groups[, dtype, . . .])	Computes the arithmetic mean.
LArray.median(*axes_and_groups[, out, . . .])	Computes the arithmetic median.
LArray.median_by(*axes_and_groups[, out, . . .])	Computes the arithmetic median.
LArray.var(*axes_and_groups[, dtype, ddof, . . .])	Computes the unbiased variance.
LArray.var_by(*axes_and_groups[, dtype, . . .])	Computes the unbiased variance.
LArray.std(*axes_and_groups[, dtype, ddof, . . .])	Computes the sample standard deviation.
LArray.std_by(*axes_and_groups[, dtype, . . .])	Computes the sample standard deviation.
LArray.percentile(q, *axes_and_groups[, . . .])	Computes the qth percentile of the data along the specified axis.
LArray.percentile_by(q, *axes_and_groups[, . . .])	Computes the qth percentile of the data for the specified axis.
LArray.ptp(*axes_and_groups[, out])	Returns the range of values (maximum - minimum).
LArray.with_total(*args[, op, label])	Add aggregated values (sum by default) along each axis.
LArray.percent(self, *axes)	Returns an array with values given as percent of the total of all values along given axes.
LArray.ratio(self, *axes)	Returns an array with all values divided by the sum of values along given axes.
LArray.rationot0(self, *axes)	Returns a LArray with values array / array.sum(axes) where the sum is not 0, 0 otherwise.
LArray.growth_rate(self[, axis, d, label])	Calculates the growth along a given axis.
LArray.describe(self, *args, **kwargs)	Descriptive summary statistics, excluding NaN values.
LArray.describe_by(self, *args, **kwargs)	Descriptive summary statistics, excluding NaN values, along axes or for groups.

larray.LArray.sum

LArray.**sum**(**axes_and_groups*, *dtype=None*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the sum of array elements along given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the sum is performed. The default (no axis or group) is to perform the sum over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).

- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the sum over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- ([‘a1’, ‘a3’, ‘a5’], ‘b1, b3, b5’) : labels separated by commas in a list or a string
- (‘a1:a5:2’) : select labels using a slice (general syntax is ‘start:end:step’ where is ‘step’ is optional and 1 by default).
- (a=’a1, a2, a3’, X.b[‘b1, b2, b3’]) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- (‘a1:a3; a5:a7’, b=’b0,b2; b1,b3’) : create several groups with semicolons. Names are simply given by the concatenation of labels (here: ‘a1,a2,a3’, ‘a5,a6,a7’, ‘b0,b2’ and ‘b1,b3’)
- (‘a1:a3 >> a123’, ‘b[b0,b2] >> b12’) : operator ‘ >> ‘ allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0’s and 1.0’s). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. ‘sum’, ‘prod’, . . .). It is possible to override this label by passing a specific value (e.g. keepaxes=’summation’). Defaults to False.

Returns

LArray or scalar

See also:

LArray.sum_by, *LArray.prod*, *LArray.prod_by*

LArray.cumsum, *LArray.cumprod*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.sum()
120
>>> # along axis 'a'
>>> arr.sum('a')
b  b0  b1  b2  b3
```

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```
   24  28  32  36
>>> # along axis 'b'
>>> arr.sum('b')
a  a0  a1  a2  a3
    6  22  38  54
```

Select some rows only

```
>>> arr.sum(['a0', 'a1'])
b  b0  b1  b2  b3
    4   6   8  10
>>> # or equivalently
>>> # arr.sum('a0,a1')
```

Split an axis in several parts

```
>>> arr.sum((['a0', 'a1'], ['a2', 'a3']))
  a\b  b0  b1  b2  b3
a0,a1   4   6   8  10
a2,a3  20  22  24  26
>>> # or equivalently
>>> # arr.sum('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.sum((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b  b0  b1  b2  b3
a01   4   6   8  10
a23  20  22  24  26
>>> # or equivalently
>>> # arr.sum('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.sum_by

LArray.**sum_by**(**axes_and_groups*, *dtype=None*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the sum of array elements for the given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The sum is performed along all axes except the given one(s). For groups, sum is performed along groups and non associated axes. The default (no axis or group) is to perform the sum over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the sum over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- ([‘a1’, ‘a3’, ‘a5’], ‘b1, b3, b5’) : labels separated by commas in a list or a string
- (‘a1:a5:2’) : select labels using a slice (general syntax is ‘start:end:step’ where is ‘step’ is optional and 1 by default).
- (a=’a1, a2, a3’, X.b[‘b1, b2, b3’]) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- (‘a1:a3; a5:a7’, b=’b0,b2; b1,b3’) : create several groups with semicolons. Names are simply given by the concatenation of labels (here: ‘a1,a2,a3’, ‘a5,a6,a7’, ‘b0,b2’ and ‘b1,b3’)
- (‘a1:a3 >> a123’, ‘b[b0,b2] >> b12’) : operator ‘ >> ‘ allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0’s and 1.0’s). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. ‘sum’, ‘prod’, . . .). It is possible to override this label by passing a specific value (e.g. keepaxes=’summation’). Defaults to False.

Returns

LArray or scalar

See also:

LArray.sum, *LArray.prod*, *LArray.prod_by*

LArray.cumsum, *LArray.cumprod*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.sum_by()
120
>>> # along axis 'a'
>>> arr.sum_by('a')
a  a0  a1  a2  a3
    6  22  38  54
>>> # along axis 'b'
>>> arr.sum_by('b')
```

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```
b  b0  b1  b2  b3
   24  28  32  36
```

Select some rows only

```
>>> arr.sum_by(['a0', 'a1'])
28
>>> # or equivalently
>>> # arr.sum_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.sum_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
      28     92
>>> # or equivalently
>>> # arr.sum_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.sum_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a  a01  a23
    28   92
>>> # or equivalently
>>> # arr.sum_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.prod

`LArray.prod`(**axes_and_groups*, *dtype=None*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the product of array elements along given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the product is performed. The default (no axis or group) is to perform the product over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the product over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).

- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', . . .). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.prod_by, *LArray.sum*, *LArray.sum_by*

LArray.cumsum, *LArray.cumprod*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.prod()
0
>>> # along axis 'a'
>>> arr.prod('a')
b  b0   b1    b2    b3
    0  585  1680  3465
>>> # along axis 'b'
>>> arr.prod('b')
a  a0   a1    a2     a3
    0  840  7920  32760
```

Select some rows only

```
>>> arr.prod(['a0', 'a1'])
b  b0  b1  b2  b3
    0   5  12  21
>>> # or equivalently
>>> # arr.prod('a0,a1')
```

Split an axis in several parts

```
>>> arr.prod((['a0', 'a1'], ['a2', 'a3']))
  a\b  b0   b1   b2   b3
a0,a1   0    5   12   21
a2,a3  96  117  140  165
>>> # or equivalently
>>> # arr.prod('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.prod((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b  b0   b1   b2   b3
a01   0    5   12   21
a23  96  117  140  165
>>> # or equivalently
>>> # arr.prod('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.prod_by

LArray.**prod_by**(**axes_and_groups*, *dtype=None*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the product of array elements for the given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The product is performed along all axes except the given one(s). For groups, product is performed along groups and non associated axes. The default (no axis or group) is to perform the product over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the product over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.

- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', . . .). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.prod, *LArray.sum*, *LArray.sum_by*

LArray.cumsum, *LArray.cumprod*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.prod_by()
0
>>> # along axis 'a'
>>> arr.prod_by('a')
a  a0   a1    a2     a3
    0  840  7920  32760
>>> # along axis 'b'
>>> arr.prod_by('b')
b  b0   b1    b2    b3
    0  585  1680  3465
```

Select some rows only

```
>>> arr.prod_by(['a0', 'a1'])
0
>>> # or equivalently
>>> # arr.prod_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.prod_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1      a2,a3
       0  259459200
>>> # or equivalently
>>> # arr.prod_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.prod_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a  a01        a23
     0  259459200
>>> # or equivalently
>>> # arr.prod_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.cumsum

`LArray.cumsum(self, axis=-1)`

Returns the cumulative sum of array elements along an axis.

Parameters

axis [int or str or Axis, optional] Axis along which to perform the cumulative sum. If given as position, it can be a negative integer, in which case it counts from the last to the first axis. By default, the cumulative sum is performed along the last axis.

Returns

LArray or scalar

See also:

LArray.cumprod, *LArray.sum*, *LArray.sum_by*

LArray.prod, *LArray.prod_by*

Notes

Cumulative aggregation functions accept only one axis

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.cumsum()
a\b  b0  b1  b2  b3
 a0   0   1   3   6
 a1   4   9  15  22
 a2   8  17  27  38
```

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```
 a3  12  25  39  54
>>> arr.cumsum('a')
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   6   8  10
 a2  12  15  18  21
 a3  24  28  32  36
```

larray.LArray.cumprod

LArray.**cumprod**(*self*, *axis=-1*)

Returns the cumulative product of array elements.

Parameters

axis [int or str or Axis, optional] Axis along which to perform the cumulative product. If given as position, it can be a negative integer, in which case it counts from the last to the first axis. By default, the cumulative product is performed along the last axis.

Returns

LArray or scalar

See also:

LArray.cumsum, *LArray.sum*, *LArray.sum_by*

LArray.prod, *LArray.prod_by*

Notes

Cumulative aggregation functions accept only one axis.

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.cumprod()
a\b  b0   b1    b2     b3
 a0   0    0     0      0
 a1   4   20   120    840
 a2   8   72   720   7920
 a3  12  156  2184  32760
>>> arr.cumprod('a')
a\b  b0   b1    b2    b3
 a0   0    1     2     3
 a1   0    5    12    21
 a2   0   45   120   231
 a3   0  585  1680  3465
```

larray.LArray.mean

LArray.**mean**(**axes_and_groups*, *dtype=None*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the arithmetic mean.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the mean is performed. The default (no axis or group) is to perform the mean over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the mean over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', …). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

`LArray.mean_by`, `LArray.median`, `LArray.median_by`

LArray.var, *LArray.var_by*, *LArray.std*, *LArray.std_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.mean()
7.5
>>> # along axis 'a'
>>> arr.mean('a')
b   b0   b1   b2   b3
   6.0  7.0  8.0  9.0
>>> # along axis 'b'
>>> arr.mean('b')
a   a0   a1   a2    a3
   1.5  5.5  9.5  13.5
```

Select some rows only

```
>>> arr.mean(['a0', 'a1'])
b   b0   b1   b2   b3
   2.0  3.0  4.0  5.0
>>> # or equivalently
>>> # arr.mean('a0,a1')
```

Split an axis in several parts

```
>>> arr.mean((['a0', 'a1'], ['a2', 'a3']))
  a\b    b0    b1    b2    b3
a0,a1   2.0   3.0   4.0   5.0
a2,a3  10.0  11.0  12.0  13.0
>>> # or equivalently
>>> # arr.mean('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.mean((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b    b0    b1    b2    b3
a01   2.0   3.0   4.0   5.0
a23  10.0  11.0  12.0  13.0
>>> # or equivalently
>>> # arr.mean('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.mean_by

`LArray.`**`mean_by`**(**axes_and_groups*, *dtype=None*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the arithmetic mean.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The mean is performed along all axes except the given one(s). For groups, mean is performed along groups and non associated axes. The default (no axis or group) is to perform the mean over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the mean over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.mean, *LArray.median*, *LArray.median_by*

LArray.var, *LArray.var_by*, *LArray.std*, *LArray.std_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.mean()
7.5
>>> # along axis 'a'
>>> arr.mean_by('a')
a    a0   a1   a2    a3
    1.5  5.5  9.5  13.5
>>> # along axis 'b'
>>> arr.mean_by('b')
b    b0   b1   b2   b3
    6.0  7.0  8.0  9.0
```

Select some rows only

```
>>> arr.mean_by(['a0', 'a1'])
3.5
>>> # or equivalently
>>> # arr.mean_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.mean_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
     3.5   11.5
>>> # or equivalently
>>> # arr.mean_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.mean_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a  a01   a23
   3.5  11.5
>>> # or equivalently
>>> # arr.mean_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.median

LArray.**median**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)
Computes the arithmetic median.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the median is performed. The default (no axis or group) is to perform the median over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.

- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the median over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', …). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.median_by, *LArray.mean*, *LArray.mean_by*

LArray.var, *LArray.var_by*, *LArray.std*, *LArray.std_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr[:,:] = [[10, 7, 5, 9],
...             [5, 8, 3, 7],
...             [6, 2, 0, 9],
...             [9, 10, 5, 6]]
>>> arr
a\b  b0  b1  b2  b3
 a0  10   7   5   9
 a1   5   8   3   7
 a2   6   2   0   9
```

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```
 a3   9  10   5   6
>>> arr.median()
6.5
>>> # along axis 'a'
>>> arr.median('a')
b   b0   b1   b2   b3
   7.5  7.5  4.0  8.0
>>> # along axis 'b'
>>> arr.median('b')
a   a0   a1   a2   a3
   8.0  6.0  4.0  7.5
```

Select some rows only

```
>>> arr.median(['a0', 'a1'])
b   b0   b1   b2   b3
   7.5  7.5  4.0  8.0
>>> # or equivalently
>>> # arr.median('a0,a1')
```

Split an axis in several parts

```
>>> arr.median((['a0', 'a1'], ['a2', 'a3']))
  a\b   b0   b1   b2   b3
a0,a1  7.5  7.5  4.0  8.0
a2,a3  7.5  6.0  2.5  7.5
>>> # or equivalently
>>> # arr.median('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.median((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b   b0   b1   b2   b3
a01  7.5  7.5  4.0  8.0
a23  7.5  6.0  2.5  7.5
>>> # or equivalently
>>> # arr.median('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.median_by

LArray.**median_by**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the arithmetic median.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The mediane is performed along all axes except the given one(s). For groups, median is performed along groups and non associated axes. The default (no axis or group) is to perform the mediane over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).

- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the mediane over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- ([‘a1’, ‘a3’, ‘a5’], ‘b1, b3, b5’) : labels separated by commas in a list or a string
- (‘a1:a5:2’) : select labels using a slice (general syntax is ‘start:end:step’ where is ‘step’ is optional and 1 by default).
- (a=’a1, a2, a3’, X.b[‘b1, b2, b3’]) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- (‘a1:a3; a5:a7’, b=’b0,b2; b1,b3’) : create several groups with semicolons. Names are simply given by the concatenation of labels (here: ‘a1,a2,a3’, ‘a5,a6,a7’, ‘b0,b2’ and ‘b1,b3’)
- (‘a1:a3 >> a123’, ‘b[b0,b2] >> b12’) : operator ‘ >> ‘ allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0’s and 1.0’s). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. ‘sum’, ‘prod’, . . .). It is possible to override this label by passing a specific value (e.g. keepaxes=’summation’). Defaults to False.

Returns

LArray or scalar

See also:

LArray.median, *LArray.mean*, *LArray.mean_by*

LArray.var, *LArray.var_by*, *LArray.std*, *LArray.std_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr[:,:] = [[10, 7, 5, 9],
...              [5, 8, 3, 7],
...              [6, 2, 0, 9],
...              [9, 10, 5, 6]]
>>> arr
a\b  b0  b1  b2  b3
 a0  10   7   5   9
 a1   5   8   3   7
 a2   6   2   0   9
 a3   9  10   5   6
>>> arr.median_by()
6.5
```

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```
>>> # along axis 'a'
>>> arr.median_by('a')
a    a0    a1    a2    a3
   8.0   6.0   4.0   7.5
>>> # along axis 'b'
>>> arr.median_by('b')
b    b0    b1    b2    b3
   7.5   7.5   4.0   8.0
```

Select some rows only

```
>>> arr.median_by(['a0', 'a1'])
7.0
>>> # or equivalently
>>> # arr.median_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.median_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
     7.0   5.75
>>> # or equivalently
>>> # arr.median_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.median_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a  a01    a23
   7.0   5.75
>>> # or equivalently
>>> # arr.median_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.var

`LArray.`**`var`**(**axes_and_groups*, *dtype=None*, *ddof=1*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the unbiased variance.

Normalized by N-1 by default. This can be changed using the ddof argument.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the variance is performed. The default (no axis or group) is to perform the variance over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the variance over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- ([‘a1’, ‘a3’, ‘a5’], ‘b1, b3, b5’) : labels separated by commas in a list or a string
- (‘a1:a5:2’) : select labels using a slice (general syntax is ‘start:end:step’ where is ‘step’ is optional and 1 by default).
- (a=’a1, a2, a3’, X.b[‘b1, b2, b3’]) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- (‘a1:a3; a5:a7’, b=’b0,b2; b1,b3’) : create several groups with semicolons. Names are simply given by the concatenation of labels (here: ‘a1,a2,a3’, ‘a5,a6,a7’, ‘b0,b2’ and ‘b1,b3’)
- (‘a1:a3 >> a123’, ‘b[b0,b2] >> b12’) : operator ‘ >> ‘ allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

ddof [int, optional] “Delta Degrees of Freedom”: the divisor used in the calculation is `N - ddof`, where `N` represents the number of elements. Defaults to 1.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0’s and 1.0’s). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. ‘sum’, ‘prod’, . . .). It is possible to override this label by passing a specific value (e.g. keepaxes=’summation’). Defaults to False.

Returns

LArray or scalar

See also:

LArray.var_by, *LArray.std*, *LArray.std_by*

LArray.mean, *LArray.mean_by*, *LArray.median*, *LArray.median_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((2, 8), dtype=float)
>>> arr[:,:] = [[0, 3, 5, 6, 4, 2, 1, 3],
...             [7, 3, 2, 5, 8, 5, 6, 4]]
>>> arr
a\b   b0   b1   b2   b3   b4   b5   b6   b7
 a0  0.0  3.0  5.0  6.0  4.0  2.0  1.0  3.0
 a1  7.0  3.0  2.0  5.0  8.0  5.0  6.0  4.0
>>> arr.var()
4.7999999999999998
>>> # along axis 'b'
```

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```
>>> arr.var('b')
a    a0   a1
    4.0  4.0
```

Select some columns only

```
>>> arr.var(['b0', 'b1', 'b3'])
a    a0   a1
    9.0  4.0
>>> # or equivalently
>>> # arr.var('b0,b1,b3')
```

Split an axis in several parts

```
>>> arr.var((['b0', 'b1', 'b3'], 'b5:'))
a\b  b0,b1,b3  b5:
 a0       9.0  1.0
 a1       4.0  1.0
>>> # or equivalently
>>> # arr.var('b0,b1,b3;b5:')
```

Same with renaming

```
>>> arr.var((X.b['b0', 'b1', 'b3'] >> 'b013', X.b['b5:'] >> 'b567'))
a\b  b013  b567
 a0   9.0   1.0
 a1   4.0   1.0
>>> # or equivalently
>>> # arr.var('b0,b1,b3>>b013;b5:>>b567')
```

larray.LArray.var_by

`LArray.var_by`(**axes_and_groups*, *dtype=None*, *ddof=1*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the unbiased variance.

Normalized by N-1 by default. This can be changed using the ddof argument.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The variance is performed along all axes except the given one(s). For groups, variance is performed along groups and non associated axes. The default (no axis or group) is to perform the variance over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the variance over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- ([‘a1’, ‘a3’, ‘a5’], ‘b1, b3, b5’) : labels separated by commas in a list or a string
- (‘a1:a5:2’) : select labels using a slice (general syntax is ‘start:end:step’ where is ‘step’ is optional and 1 by default).
- (a=’a1, a2, a3’, X.b[‘b1, b2, b3’]) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- (‘a1:a3; a5:a7’, b=’b0,b2; b1,b3’) : create several groups with semicolons. Names are simply given by the concatenation of labels (here: ‘a1,a2,a3’, ‘a5,a6,a7’, ‘b0,b2’ and ‘b1,b3’)
- (‘a1:a3 >> a123’, ‘b[b0,b2] >> b12’) : operator ‘ >> ‘ allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

ddof [int, optional] “Delta Degrees of Freedom”: the divisor used in the calculation is `N - ddof`, where `N` represents the number of elements. Defaults to 1.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0’s and 1.0’s). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. ‘sum’, ‘prod’, . . .). It is possible to override this label by passing a specific value (e.g. keepaxes=’summation’). Defaults to False.

Returns

LArray or scalar

See also:

LArray.var, *LArray.std*, *LArray.std_by*

LArray.mean, *LArray.mean_by*, *LArray.median*, *LArray.median_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((2, 8), dtype=float)
>>> arr[:,:] = [[0, 3, 5, 6, 4, 2, 1, 3],
...             [7, 3, 2, 5, 8, 5, 6, 4]]
>>> arr
a\b   b0   b1   b2   b3   b4   b5   b6   b7
 a0  0.0  3.0  5.0  6.0  4.0  2.0  1.0  3.0
 a1  7.0  3.0  2.0  5.0  8.0  5.0  6.0  4.0
>>> arr.var_by()
4.7999999999999998
>>> # along axis 'a'
>>> arr.var_by('a')
a    a0   a1
    4.0  4.0
```

Select some columns only

```
>>> arr.var_by('a', ['b0','b1','b3'])
a    a0    a1
   9.0   4.0
>>> # or equivalently
>>> # arr.var_by('a','b0,b1,b3')
```

Split an axis in several parts

```
>>> arr.var_by('a', (['b0', 'b1', 'b3'], 'b5:'))
a\b  b0,b1,b3  b5:
 a0       9.0  1.0
 a1       4.0  1.0
>>> # or equivalently
>>> # arr.var_by('a','b0,b1,b3;b5:')
```

Same with renaming

```
>>> arr.var_by('a', (X.b['b0', 'b1', 'b3'] >> 'b013', X.b['b5:'] >> 'b567'))
a\b  b013  b567
 a0   9.0   1.0
 a1   4.0   1.0
>>> # or equivalently
>>> # arr.var_by('a','b0,b1,b3>>b013;b5:>>b567')
```

larray.LArray.std

`LArray.std`(**axes_and_groups*, *dtype=None*, *ddof=1*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the sample standard deviation.

Normalized by N-1 by default. This can be changed using the ddof argument.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the standard deviation is performed. The default (no axis or group) is to perform the standard deviation over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the standard deviation over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).

- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

ddof [int, optional] "Delta Degrees of Freedom": the divisor used in the calculation is `N - ddof`, where `N` represents the number of elements. Defaults to 1.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', . . .). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.std_by, *LArray.var*, *LArray.var_by*

LArray.mean, *LArray.mean_by*, *LArray.median*, *LArray.median_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((2, 8), dtype=float)
>>> arr[:,:] = [[0, 3, 5, 6, 4, 2, 1, 3],
...             [7, 3, 2, 5, 8, 5, 6, 4]]
>>> arr
a\b   b0   b1   b2   b3   b4   b5   b6   b7
 a0  0.0  3.0  5.0  6.0  4.0  2.0  1.0  3.0
 a1  7.0  3.0  2.0  5.0  8.0  5.0  6.0  4.0
>>> arr.std()
2.1908902300206643
>>> # along axis 'b'
>>> arr.std('b')
a    a0   a1
    2.0  2.0
```

Select some columns only

```
>>> arr.std(['b0', 'b1', 'b3'])
a    a0   a1
   3.0  2.0
>>> # or equivalently
>>> # arr.std('b0,b1,b3')
```

Split an axis in several parts

```
>>> arr.std((['b0', 'b1', 'b3'], 'b5:'))
a\b  b0,b1,b3  b5:
 a0       3.0  1.0
 a1       2.0  1.0
>>> # or equivalently
>>> # arr.std('b0,b1,b3;b5:')
```

Same with renaming

```
>>> arr.std((X.b['b0', 'b1', 'b3'] >> 'b013', X.b['b5:'] >> 'b567'))
a\b  b013  b567
 a0   3.0   1.0
 a1   2.0   1.0
>>> # or equivalently
>>> # arr.std('b0,b1,b3>>b013;b5:>>b567')
```

larray.LArray.std_by

LArray.**std_by**(**axes_and_groups*, *dtype=None*, *ddof=1*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the sample standard deviation.

Normalized by N-1 by default. This can be changed using the ddof argument.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The standard deviation is performed along all axes except the given one(s). For groups, standard deviation is performed along groups and non associated axes. The default (no axis or group) is to perform the standard deviation over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the standard deviation over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).

- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

dtype [dtype, optional] The data type of the returned array. Defaults to None (the dtype of the input array).

ddof [int, optional] "Delta Degrees of Freedom": the divisor used in the calculation is `N - ddof`, where `N` represents the number of elements. Defaults to 1.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', . . .). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.std_by, *LArray.var*, *LArray.var_by*

LArray.mean, *LArray.mean_by*, *LArray.median*, *LArray.median_by*

LArray.percentile, *LArray.percentile_by*

Examples

```
>>> arr = ndtest((2, 8), dtype=float)
>>> arr[:,:] = [[0, 3, 5, 6, 4, 2, 1, 3],
...             [7, 3, 2, 5, 8, 5, 6, 4]]
>>> arr
a\b   b0   b1   b2   b3   b4   b5   b6   b7
 a0  0.0  3.0  5.0  6.0  4.0  2.0  1.0  3.0
 a1  7.0  3.0  2.0  5.0  8.0  5.0  6.0  4.0
>>> arr.std_by()
2.1908902300206643
>>> # along axis 'a'
>>> arr.std_by('a')
a   a0   a1
   2.0  2.0
```

Select some columns only

```
>>> arr.std_by('a', ['b0','b1','b3'])
a    a0    a1
   3.0   2.0
>>> # or equivalently
>>> # arr.std_by('a','b0,b1,b3')
```

Split an axis in several parts

```
>>> arr.std_by('a', (['b0', 'b1', 'b3'], 'b5:'))
a\b  b0,b1,b3  b5:
 a0       3.0  1.0
 a1       2.0  1.0
>>> # or equivalently
>>> # arr.std_by('a','b0,b1,b3;b5:')
```

Same with renaming

```
>>> arr.std_by('a', (X.b['b0', 'b1', 'b3'] >> 'b013', X.b['b5:'] >> 'b567'))
a\b  b013  b567
 a0   3.0   1.0
 a1   2.0   1.0
>>> # or equivalently
>>> # arr.std_by('a','b0,b1,b3>>b013;b5:>>b567')
```

larray.LArray.percentile

`LArray.`**`percentile`**(*q*, **axes_and_groups*, *out=None*, *interpolation='linear'*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the qth percentile of the data along the specified axis.

Parameters

q [int in range of [0,100] (or sequence of floats)] Percentile to compute, which must be between 0 and 100 inclusive.

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the qth percentile is performed. The default (no axis or group) is to perform the qth percentile over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the qth percentile over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).

- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

interpolation [{'linear', 'lower', 'higher', 'midpoint', 'nearest'}, optional] Interpolation method to use when the desired quantile lies between two data points `i < j`:

- linear: `i + (j - i) * fraction`, where `fraction` is the fractional part of the index surrounded by `i` and `j`.
- lower: `i`.
- higher: `j`.
- nearest: `i` or `j`, whichever is nearest.
- midpoint: `(i + j) / 2`.

Defaults to 'linear'.

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.percentile_by, *LArray.mean*, *LArray.mean_by*

LArray.median, *LArray.median_by*, *LArray.var*, *LArray.var_by*

LArray.std, *LArray.std_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.percentile(25)
3.75
```

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```
>>> # along axis 'a'
>>> arr.percentile(25, 'a')
b   b0   b1   b2   b3
   3.0  4.0  5.0  6.0
>>> # along axis 'b'
>>> arr.percentile(25, 'b')
a    a0    a1    a2     a3
   0.75  4.75  8.75  12.75
>>> # several percentile values
>>> arr.percentile([25, 50, 75], 'b')
percentile\a    a0    a1     a2     a3
          25  0.75  4.75   8.75  12.75
          50   1.5   5.5    9.5   13.5
          75  2.25  6.25  10.25  14.25
```

Select some rows only

```
>>> arr.percentile(25, ['a0', 'a1'])
b   b0   b1   b2   b3
   1.0  2.0  3.0  4.0
>>> # or equivalently
>>> # arr.percentile(25, 'a0,a1')
```

Split an axis in several parts

```
>>> arr.percentile(25, (['a0', 'a1'], ['a2', 'a3']))
  a\b   b0    b1    b2    b3
a0,a1  1.0   2.0   3.0   4.0
a2,a3  9.0  10.0  11.0  12.0
>>> # or equivalently
>>> # arr.percentile(25, 'a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.percentile(25, (X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b   b0    b1    b2    b3
a01  1.0   2.0   3.0   4.0
a23  9.0  10.0  11.0  12.0
>>> # or equivalently
>>> # arr.percentile(25, 'a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.percentile_by

`LArray.`**`percentile_by`**(*q*, **axes_and_groups*, *out=None*, *interpolation='linear'*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Computes the qth percentile of the data for the specified axis.

Parameters

q [int in range of [0,100] (or sequence of floats)] Percentile to compute, which must be between 0 and 100 inclusive.

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The qth percentile is performed along all axes except the given one(s). For groups, qth percentile is performed along groups and non associated axes. The default (no axis or group) is to perform the qth percentile over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the qth percentile over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

interpolation [{'linear', 'lower', 'higher', 'midpoint', 'nearest'}, optional] Interpolation method to use when the desired quantile lies between two data points `i < j`:

- linear: `i + (j - i) * fraction`, where `fraction` is the fractional part of the index surrounded by `i` and `j`.
- lower: `i`.
- higher: `j`.
- nearest: `i` or `j`, whichever is nearest.
- midpoint: `(i + j) / 2`.

Defaults to 'linear'.

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', . . .). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.percentile, *LArray.mean*, *LArray.mean_by*

LArray.median, *LArray.median_by*, *LArray.var*, *LArray.var_by*
LArray.std, *LArray.std_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.percentile_by(25)
3.75
>>> # along axis 'a'
>>> arr.percentile_by(25, 'a')
a     a0    a1    a2     a3
   0.75  4.75  8.75  12.75
>>> # along axis 'b'
>>> arr.percentile_by(25, 'b')
b   b0   b1   b2   b3
   3.0  4.0  5.0  6.0
>>> # several percentile values
>>> arr.percentile_by([25, 50, 75], 'b')
percentile\b   b0    b1    b2    b3
          25  3.0   4.0   5.0   6.0
          50  6.0   7.0   8.0   9.0
          75  9.0  10.0  11.0  12.0
```

Select some rows only

```
>>> arr.percentile_by(25, ['a0', 'a1'])
1.75
>>> # or equivalently
>>> # arr.percentile_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.percentile_by(25, (['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
    1.75   9.75
>>> # or equivalently
>>> # arr.percentile_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.percentile_by(25, (X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a    a01   a23
   1.75  9.75
>>> # or equivalently
>>> # arr.percentile_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.ptp

`LArray.ptp(*axes_and_groups, out=None, **explicit_axes)`

Returns the range of values (maximum - minimum).

The name of the function comes from the acronym for 'peak to peak'.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the ptp is performed. The default (no axis or group) is to perform the ptp over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the ptp over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

Returns

LArray or scalar

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.ptp()
```

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```
15
>>> # along axis 'a'
>>> arr.ptp('a')
b  b0  b1  b2  b3
   12  12  12  12
>>> # along axis 'b'
>>> arr.ptp('b')
a  a0  a1  a2  a3
    3   3   3   3
```

Select some rows only

```
>>> arr.ptp(['a0', 'a1'])
b  b0  b1  b2  b3
    4   4   4   4
>>> # or equivalently
>>> # arr.ptp('a0,a1')
```

Split an axis in several parts

```
>>> arr.ptp((['a0', 'a1'], ['a2', 'a3']))
  a\b  b0  b1  b2  b3
a0,a1   4   4   4   4
a2,a3   4   4   4   4
>>> # or equivalently
>>> # arr.ptp('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.ptp((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b  b0  b1  b2  b3
a01   4   4   4   4
a23   4   4   4   4
>>> # or equivalently
>>> # arr.ptp('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.with_total

`LArray.`**`with_total`**(**args*, *op=sum*, *label='total'*, ***kwargs*)

Add aggregated values (sum by default) along each axis. A user defined label can be given to specified the computed values.

Parameters

***args** [int or str or Axis or Group or any combination of those, optional] Axes or groups along which to compute the aggregates. Passed groups should be named. Defaults to aggregate over the whole array.

op [aggregate function, optional] Available aggregate functions are: *sum*, *prod*, *min*, *max*, *mean*, *ptp*, *var*, *std*, *median* and *percentile*. Defaults to *sum*.

label [scalar value, optional] Label to use for the total. Applies only to aggregated axes, not groups. Defaults to “total”.

****kwargs** [int or str or Group or any combination of those, optional] Axes or groups along which to compute the aggregates.

Returns

LArray

Examples

```
>>> arr = ndtest("gender=M,F;time=2013..2016")
>>> arr
gender\time  2013  2014  2015  2016
          M     0     1     2     3
          F     4     5     6     7
>>> arr.with_total()
gender\time  2013  2014  2015  2016  total
          M     0     1     2     3      6
          F     4     5     6     7     22
      total     4     6     8    10     28
```

Using another function and label

```
>>> arr.with_total(op=mean, label='mean')
gender\time  2013  2014  2015  2016  mean
          M   0.0   1.0   2.0   3.0   1.5
          F   4.0   5.0   6.0   7.0   5.5
       mean   2.0   3.0   4.0   5.0   3.5
```

Specifying an axis and a label

```
>>> arr.with_total('gender', label='U')
gender\time  2013  2014  2015  2016
          M     0     1     2     3
          F     4     5     6     7
          U     4     6     8    10
```

Using groups

```
>>> time_groups = (arr.time[:2014] >> 'before_2015',
...                arr.time[2015:] >> 'after_2015')
>>> arr.with_total(time_groups)
gender\time  2013  2014  2015  2016  before_2015  after_2015
          M     0     1     2     3            1           5
          F     4     5     6     7            9          13
>>> # or equivalently
>>> # arr.with_total('time[:2014] >> before_2015; time[2015:] >> after_2015')
```

larray.LArray.percent

`LArray.percent` (*self*, **axes*)

Returns an array with values given as percent of the total of all values along given axes.

Parameters

***axes**

Returns

LArray array / array.sum(axes) * 100

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> a = LArray([[4, 6], [2, 8]], [nat, sex])
>>> a
nat\sex  M  F
     BE  4  6
     FO  2  8
>>> a.percent()
nat\sex     M     F
     BE  20.0  30.0
     FO  10.0  40.0
>>> a.percent('sex')
nat\sex     M     F
     BE  40.0  60.0
     FO  20.0  80.0
```

larray.LArray.ratio

LArray.**ratio**(*self*, **axes*)

Returns an array with all values divided by the sum of values along given axes.

Parameters

***axes**

Returns

LArray array / array.sum(axes)

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> a = LArray([[4, 6], [2, 8]], [nat, sex])
>>> a
nat\sex  M  F
     BE  4  6
     FO  2  8
>>> a.sum()
20
>>> a.ratio()
nat\sex    M    F
     BE  0.2  0.3
     FO  0.1  0.4
>>> a.ratio('sex')
nat\sex    M    F
     BE  0.4  0.6
     FO  0.2  0.8
>>> a.ratio('M')
nat\sex    M    F
     BE  1.0  1.5
     FO  1.0  4.0
```

larray.LArray.rationot0

`LArray.rationot0(self, *axes)`
Returns a LArray with values array / array.sum(axes) where the sum is not 0, 0 otherwise.

Parameters

***axes**

Returns

LArray array / array.sum(axes)

Examples

```
>>> a = Axis('a=a0,a1')
>>> b = Axis('b=b0,b1,b2')
>>> arr = LArray([[6, 0, 2],
...               [4, 0, 8]], [a, b])
>>> arr
a\b  b0  b1  b2
 a0   6   0   2
 a1   4   0   8
>>> arr.sum()
20
>>> arr.rationot0()
a\b   b0   b1   b2
 a0  0.3  0.0  0.1
 a1  0.2  0.0  0.4
>>> arr.rationot0('a')
a\b   b0   b1   b2
 a0  0.6  0.0  0.2
 a1  0.4  0.0  0.8
```

for reference, the normal ratio method would return:

```
>>> arr.ratio('a')
a\b   b0   b1   b2
 a0  0.6  nan  0.2
 a1  0.4  nan  0.8
```

larray.LArray.growth_rate

`LArray.growth_rate(self, axis=-1, d=1, label='upper')`
Calculates the growth along a given axis.

Roughly equivalent to a.diff(axis, d, label) / a[axis.i[:-d]]

Parameters

axis [int, str, Group or Axis, optional] Axis or group along which the difference is taken. Defaults to the last axis.

d [int, optional] Periods to shift for forming difference. Defaults to 1.

label [{'lower', 'upper'}, optional] The new labels in *axis* will have the labels of either the array being subtracted ('lower') or the array it is subtracted from ('upper'). Defaults to 'upper'.

Returns

LArray

Examples

```
>>> data = [[2, 4, 5, 4, 6], [4, 6, 3, 6, 9]]
>>> a = LArray(data, "sex=M,F; year=2016..2020")
>>> a
sex\year  2016  2017  2018  2019  2020
       M     2     4     5     4     6
       F     4     6     3     6     9
>>> a.growth_rate()
sex\year  2017  2018  2019  2020
       M   1.0  0.25  -0.2   0.5
       F   0.5  -0.5   1.0   0.5
>>> a.growth_rate(label='lower')
sex\year  2016  2017  2018  2019
       M   1.0  0.25  -0.2   0.5
       F   0.5  -0.5   1.0   0.5
>>> a.growth_rate(d=2)
sex\year   2018  2019  2020
       M    1.5   0.0   0.2
       F  -0.25   0.0   2.0
>>> a.growth_rate('sex')
sex\year  2016  2017  2018  2019  2020
       F   1.0   0.5  -0.4   0.5   0.5
>>> a.growth_rate(a.year[2017:])
sex\year  2018  2019  2020
       M  0.25  -0.2   0.5
       F  -0.5   1.0   0.5
```

larray.LArray.describe

`LArray.describe`(*self*, **args*, ***kwargs*)

Descriptive summary statistics, excluding NaN values.

By default, it includes the number of non-NaN values, the mean, standard deviation, minimum, maximum and the 25, 50 and 75 percentiles.

Parameters

***args** [int or str or Axis or Group or any combination of those, optional] Axes or groups along which to compute the aggregates. Defaults to aggregate over the whole array.

percentiles [array-like, optional.] List of integer percentiles to include. Defaults to [25, 50, 75].

Returns

LArray

See also:

LArray.describe_by

Examples

```
>>> arr = LArray([0, 6, 2, 5, 4, 3, 1, 3], 'year=2013..2020')
>>> arr
year  2013  2014  2015  2016  2017  2018  2019  2020
         0     6     2     5     4     3     1     3
>>> arr.describe()
statistic  count  mean  std  min   25%  50%   75%  max
             8.0   3.0  2.0  0.0  1.75  3.0  4.25  6.0
>>> arr.describe(percentiles=[50, 90])
statistic  count  mean  std  min  50%  90%  max
             8.0   3.0  2.0  0.0  3.0  5.3  6.0
```

larray.LArray.describe_by

`LArray.describe_by(self, *args, **kwargs)`

Descriptive summary statistics, excluding NaN values, along axes or for groups.

By default, it includes the number of non-NaN values, the mean, standard deviation, minimum, maximum and the 25, 50 and 75 percentiles.

Parameters

***args** [int or str or Axis or Group or any combination of those, optional] Axes or groups to include in the result after aggregating. Defaults to aggregate over the whole array.

percentiles [array-like, optional.] list of integer percentiles to include. Defaults to [25, 50, 75].

Returns

LArray

See also:

LArray.describe

Examples

```
>>> data = [[0, 6, 3, 5, 4, 2, 1, 3], [7, 5, 3, 2, 8, 5, 6, 4]]
>>> arr = LArray(data, 'gender=Male,Female;year=2013..2020').astype(float)
>>> arr
gender\year  2013  2014  2015  2016  2017  2018  2019  2020
       Male   0.0   6.0   3.0   5.0   4.0   2.0   1.0   3.0
     Female   7.0   5.0   3.0   2.0   8.0   5.0   6.0   4.0
>>> arr.describe_by('gender')
gender\statistic  count  mean  std  min   25%  50%   75%  max
            Male    8.0   3.0  2.0  0.0  1.75  3.0  4.25  6.0
          Female    8.0   5.0  2.0  2.0  3.75  5.0  6.25  8.0
>>> arr.describe_by('gender', (X.year[:2015], X.year[2018:]))
gender  year\statistic  count  mean  std  min  25%  50%  75%  max
  Male           :2015    3.0   3.0  3.0  0.0  1.5  3.0  4.5  6.0
  Male           2018:    3.0   2.0  1.0  1.0  1.5  2.0  2.5  3.0
Female           :2015    3.0   5.0  2.0  3.0  4.0  5.0  6.0  7.0
Female           2018:    3.0   5.0  1.0  4.0  4.5  5.0  5.5  6.0
>>> arr.describe_by('gender', percentiles=[50, 90])
gender\statistic  count  mean  std  min  50%  90%  max
```

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```
          Male     8.0   3.0  2.0  0.0  3.0  5.3  6.0
        Female     8.0   5.0  2.0  2.0  5.0  7.3  8.0
```

Sorting

LArray.sort_axes(self[, axes, ascending])	Sorts axes of the array.
LArray.sort_values(self[, key, axis, ascending])	Sorts values of the array.
LArray.labelsofsorted(self[, axis, ...])	Returns the labels that would sort this array.
LArray.indicesofsorted(self[, axis, ...])	Returns the indices that would sort this array.

larray.LArray.sort_axes

LArray.**sort_axes**(*self*, *axes=None*, *ascending=True*)

Sorts axes of the array.

Parameters

axes [axis reference (Axis, str, int) or list of them, optional] Axes to sort. Defaults to all axes.

ascending [bool, optional] Sort axes in ascending order. Defaults to True.

Returns

LArray Array with sorted axes.

Examples

```
>>> a = ndtest("nat=EU,FO,BE; sex=M,F")
>>> a
nat\sex  M  F
     EU  0  1
     FO  2  3
     BE  4  5
>>> a.sort_axes('sex')
nat\sex  F  M
     EU  1  0
     FO  3  2
     BE  5  4
>>> a.sort_axes()
nat\sex  F  M
     BE  5  4
     EU  1  0
     FO  3  2
>>> a.sort_axes(('sex', 'nat'))
nat\sex  F  M
     BE  5  4
     EU  1  0
     FO  3  2
>>> a.sort_axes(ascending=False)
nat\sex  M  F
     FO  2  3
     EU  0  1
     BE  4  5
```

larray.LArray.sort_values

`LArray.sort_values(self, key=None, axis=None, ascending=True)`

Sorts values of the array.

Parameters

key [scalar or tuple or Group] Key along which to sort. Must have exactly one dimension less than ndim. Cannot be used in combination with *axis* argument. If both *key* and *axis* are None, sort array with all axes combined. Defaults to None.

axis [int or str or Axis] Axis along which to sort. Cannot be used in combination with *key* argument. Defaults to None.

ascending [bool, optional] Sort values in ascending order. Defaults to True.

Returns

LArray Array with sorted values.

Examples

sort the whole array (no key or axis given)

```
>>> arr_1D = LArray([10, 2, 4], 'a=a0..a2')
>>> arr_1D
a  a0  a1  a2
   10   2   4
>>> arr_1D.sort_values()
a  a1  a2  a0
    2   4  10
>>> arr_2D = LArray([[10, 2, 4], [3, 7, 1]], 'a=a0,a1; b=b0..b2')
>>> arr_2D
a\b  b0  b1  b2
 a0  10   2   4
 a1   3   7   1
>>> # if the array has more than one dimension, sort array with all axes combined
>>> arr_2D.sort_values()
a_b  a1_b2  a0_b1  a1_b0  a0_b2  a1_b1  a0_b0
         1      2      3      4      7     10
```

Sort along a given key

```
>>> # sort columns according to the values of the row associated with the label
↪'a1'
>>> arr_2D.sort_values('a1')
a\b  b2  b0  b1
 a0   4  10   2
 a1   1   3   7
>>> arr_2D.sort_values('a1', ascending=False)
a\b  b1  b0  b2
 a0   2  10   4
 a1   7   3   1
>>> arr_3D = LArray([[[10, 2, 4], [3, 7, 1]], [[5, 1, 6], [2, 8, 9]]],
...                 'a=a0,a1; b=b0,b1; c=c0..c2')
>>> arr_3D
 a  b\c  c0  c1  c2
a0   b0  10   2   4
```

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```
a0   b1   3   7   1
a1   b0   5   1   6
a1   b1   2   8   9
>>> # sort columns according to the values of the row associated with the labels
↪'a0' and 'b1'
>>> arr_3D.sort_values(('a0', 'b1'))
 a  b\c  c2  c0  c1
a0   b0   4  10   2
a0   b1   1   3   7
a1   b0   6   5   1
a1   b1   9   2   8
```

Sort along an axis

```
>>> arr_2D
a\b  b0  b1  b2
 a0  10   2   4
 a1   3   7   1
>>> # sort values along axis 'a'
>>> # equivalent to sorting the values of each column of the array
>>> arr_2D.sort_values(axis='a')
a*\b  b0  b1  b2
   0   3   2   1
   1  10   7   4
>>> # sort values along axis 'b'
>>> # equivalent to sorting the values of each row of the array
>>> arr_2D.sort_values(axis='b')
a\b*  0  1   2
  a0  2  4  10
  a1  1  3   7
```

larray.LArray.labelsofsorted

LArray.**labelsofsorted**(*self*, *axis=None*, *ascending=True*, *kind='quicksort'*)

Returns the labels that would sort this array.

Performs an indirect sort along the given axis using the algorithm specified by the *kind* keyword. It returns an array of labels of the same shape as *a* that index data along the given axis in sorted order.

Parameters

axis [int or str or Axis, optional] Axis along which to sort. This can be omitted if array has only one axis.

ascending [bool, optional] Sort values in ascending order. Defaults to True.

kind [{'quicksort', 'mergesort', 'heapsort'}, optional] Sorting algorithm. Defaults to 'quicksort'.

Returns

LArray

Examples

```
>>> arr = LArray([[0, 1], [3, 2], [2, 5]], "nat=BE,FR,IT; sex=M,F")
>>> arr
nat\sex  M  F
     BE  0  1
     FR  3  2
     IT  2  5
>>> arr.labelsofsorted('sex')
nat\sex  0  1
     BE  M  F
     FR  F  M
     IT  M  F
>>> arr.labelsofsorted('sex', ascending=False)
nat\sex  0  1
     BE  F  M
     FR  M  F
     IT  F  M
```

larray.LArray.indicesofsorted

`LArray.`**`indicesofsorted`**(*self*, *axis=None*, *ascending=True*, *kind='quicksort'*)

Returns the indices that would sort this array.

Performs an indirect sort along the given axis using the algorithm specified by the *kind* keyword. It returns an array of indices with the same axes as *a* that index data along the given axis in sorted order.

Parameters

axis [int or str or Axis, optional] Axis along which to sort. This can be omitted if array has only one axis.

ascending [bool, optional] Sort values in ascending order. Defaults to True.

kind [{'quicksort', 'mergesort', 'heapsort'}, optional] Sorting algorithm. Defaults to 'quicksort'.

Returns

LArray

Examples

```
>>> arr = LArray([[1, 5], [3, 2], [0, 4]], "nat=BE,FR,IT; sex=M,F")
>>> arr
nat\sex  M  F
     BE  1  5
     FR  3  2
     IT  0  4
>>> arr.indicesofsorted('nat')
nat\sex  M  F
      0  2  1
      1  0  2
      2  1  0
>>> arr.indicesofsorted('nat', ascending=False)
nat\sex  M  F
```

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```
        0   1   0
        1   0   2
        2   2   1
```

Reshaping/Extending/Reordering

LArray.reshape(self, target_axes)	Given a list of new axes, changes the shape of the array.
LArray.reshape_like(self, target)	Same as reshape but with an array as input.
LArray.compact(self)	Detects and removes "useless" axes (ie axes for which values are constant over the whole axis)
LArray.reindex(self[, axes_to_reindex, ...])	Reorder and/or add new labels in axes.
LArray.transpose(self, *args)	Reorder axes.
LArray.expand(self[, target_axes, out, readonly])	Expands array to target_axes.
LArray.prepend(self, axis, value[, label])	Adds an array before self along an axis.
LArray.append(self, axis, value[, label])	Adds an array to self along an axis.
LArray.extend(self, axis, other)	Adds an array to self along an axis.
LArray.insert(self, value[, before, after, ...])	Inserts value in array along an axis.
LArray.broadcast_with(self, target)	Returns an array that is (NumPy) broadcastable with target.
LArray.align(self, other[, join, ...])	Align two arrays on their axes with the specified join method.

larray.LArray.reshape

LArray.**reshape**(*self*, *target_axes*)

Given a list of new axes, changes the shape of the array. The size of the array (= number of elements) must be equal to the product of length of target axes.

Parameters

target_axes [iterable of Axis] New axes. The size of the array (= number of stored data) must be equal to the product of length of target axes.

Returns

LArray New array with new axes but same data.

Examples

```
>>> arr = ndtest((2, 2, 2))
>>> arr
 a  b\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
>>> new_arr = arr.reshape([Axis('a=a0,a1'),
... Axis(['b0c0', 'b0c1', 'b1c0', 'b1c1'], 'bc')])
>>> new_arr
a\bc  b0c0  b0c1  b1c0  b1c1
  a0     0     1     2     3
  a1     4     5     6     7
```

larray.LArray.reshape_like

LArray.**reshape_like**(*self*, *target*)

Same as reshape but with an array as input. Total size (= number of stored data) of the two arrays must be equal.

See also:

reshape returns a LArray with a new shape given a list of axes.

Examples

```
>>> arr = zeros((2, 2, 2), dtype=int)
>>> arr
{0}*  {1}*\{2}*  0  1
   0          0  0  0
   0          1  0  0
   1          0  0  0
   1          1  0  0
>>> new_arr = arr.reshape_like(ndtest((2, 4)))
>>> new_arr
a\b  b0  b1  b2  b3
 a0   0   0   0   0
 a1   0   0   0   0
```

larray.LArray.compact

LArray.**compact**(*self*)

Detects and removes "useless" axes (ie axes for which values are constant over the whole axis)

Returns

LArray or scalar Array with constant axes removed.

Examples

```
>>> a = LArray([[1, 2],
...             [1, 2]], [Axis('sex=M,F'), Axis('nat=BE,FO')])
>>> a
sex\nat  BE  FO
      M   1   2
      F   1   2
>>> a.compact()
nat  BE  FO
      1   2
```

larray.LArray.reindex

LArray.**reindex**(*self*, *axes_to_reindex=None*, *new_axis=None*, *fill_value=nan*, *inplace=False*, ***kwargs*)

Reorder and/or add new labels in axes.

Place NaN or given *fill_value* in locations having no value previously.

Parameters

axes_to_reindex [axis ref or dict {axis ref: axis} or list of (axis ref, axis) or sequence of Axis] Axis(es) to reindex. If a single axis reference is given, the *new_axis* argument must be provided. If string, Group or Axis object, the corresponding axis is reindexed if found among existing, otherwise a new axis is added. If a list of Axis or an AxisCollection is given, existing axes are reindexed while missing ones are added.

new_axis [int, str, list/tuple/array of str, Group or Axis, optional] List of new labels or new axis if *axes_to_reindex* contains a single axis reference.

fill_value [scalar or LArray, optional] Value used to fill cells corresponding to label combinations which were not present before reindexing. Defaults to NaN.

inplace [bool, optional] Whether or not to modify the original object or return a new array and leave the original intact. Defaults to False.

****kwargs** [Axis] New axis for each axis to reindex given as a keyword argument.

Returns

LArray Array with reindexed axes.

Notes

When introducing NaNs into an array containing integers via reindex, all data will be promoted to float in order to store the NaNs.

Examples

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> arr2 = ndtest('a=a1,a2;c=c0;b=b2..b0')
>>> arr2
 a  c\b  b2  b1  b0
a1   c0   0   1   2
a2   c0   3   4   5
```

Reindex an axis by passing labels (list or string)

```
>>> arr.reindex('b', ['b1', 'b2', 'b0'])
a\b   b1   b2   b0
 a0  1.0  nan  0.0
 a1  3.0  nan  2.0
>>> arr.reindex('b', 'b0..b2', fill_value=-1)
a\b  b0  b1  b2
 a0   0   1  -1
 a1   2   3  -1
>>> arr.reindex(b='b=b0..b2', fill_value=-1)
a\b  b0  b1  b2
 a0   0   1  -1
 a1   2   3  -1
```

Reindex using an axis from another array

```
>>> arr.reindex('b', arr2.b, fill_value=-1)
a\b  b2  b1  b0
 a0  -1   1   0
 a1  -1   3   2
```

Reindex using a subset of an axis

```
>>> arr.reindex('b', arr2.b['b1':], fill_value=-1)
a\b  b1  b0
 a0   1   0
 a1   3   2
```

Reindex by passing an axis or a group

```
>>> arr.reindex('b=b2..b0', fill_value=-1)
a\b  b2  b1  b0
 a0  -1   1   0
 a1  -1   3   2
>>> arr.reindex(arr2.b, fill_value=-1)
a\b  b2  b1  b0
 a0  -1   1   0
 a1  -1   3   2
>>> arr.reindex(arr2.b['b1':], fill_value=-1)
a\b  b1  b0
 a0   1   0
 a1   3   2
```

Reindex several axes

```
>>> arr.reindex({'a': arr2.a, 'b': arr2.b}, fill_value=-1)
a\b  b2  b1  b0
 a1  -1   3   2
 a2  -1  -1  -1
>>> arr.reindex({'a': arr2.a, 'b': arr2.b['b1':]}, fill_value=-1)
a\b  b1  b0
 a1   3   2
 a2  -1  -1
>>> arr.reindex(a=arr2.a, b=arr2.b, fill_value=-1)
a\b  b2  b1  b0
 a1  -1   3   2
 a2  -1  -1  -1
```

Reindex by passing a collection of axes

```
>>> arr.reindex(arr2.axes, fill_value=-1)
 a  b\c  c0
a1   b2  -1
a1   b1   3
a1   b0   2
a2   b2  -1
a2   b1  -1
a2   b0  -1
>>> arr2.reindex(arr.axes, fill_value=-1)
 a  c\b  b0  b1
a0   c0  -1  -1
a1   c0   2   1
```

larray.LArray.transpose

LArray.**transpose**(*self*, **args*)
Reorder axes.

By default, reverse axes, otherwise permute the axes according to the list given as argument.

Parameters

***args** Accepts either a tuple of axes specs or axes specs as **args*. Omitted axes keep their order. Use ... to avoid specifying intermediate axes.

Returns

LArray LArray with reordered axes.

Examples

```
>>> arr = ndtest((2, 2, 2))
>>> arr
 a  b\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
>>> arr.transpose('b', 'c', 'a')
 b  c\a  a0  a1
b0   c0   0   4
b0   c1   1   5
b1   c0   2   6
b1   c1   3   7
>>> arr.transpose('b')
 b  a\c  c0  c1
b0   a0   0   1
b0   a1   4   5
b1   a0   2   3
b1   a1   6   7
>>> arr.transpose(..., 'a')  # doctest: +SKIP
 b  c\a  a0  a1
b0   c0   0   4
b0   c1   1   5
b1   c0   2   6
b1   c1   3   7
>>> arr.transpose('c', ..., 'a')  # doctest: +SKIP
 c  b\a  a0  a1
c0   b0   0   4
c0   b1   2   6
c1   b0   1   5
c1   b1   3   7
```

larray.LArray.expand

LArray.**expand**(*self*, *target_axes=None*, *out=None*, *readonly=False*)
Expands array to target_axes.

Target axes will be added to array if not present. In most cases this function is not needed because LArray can do operations with arrays having different (compatible) axes.

Parameters

target_axes [string, list of Axis or AxisCollection, optional] Self can contain axes not present in *target_axes*. The result axes will be: [self.axes not in target_axes] + target_axes

out [LArray, optional] Output array, must have more axes than array. Defaults to a new array. arr.expand(out=out) is equivalent to out[:] = arr

readonly [bool, optional] Whether returning a readonly view is acceptable or not (this is much faster)

Returns

LArray Original array if possible (and out is None).

Examples

```
>>> a = Axis('a=a1,a2')
>>> b = Axis('b=b1,b2')
>>> arr = ndtest([a, b])
>>> arr
a\b  b1  b2
 a1   0   1
 a2   2   3
```

Adding one or several axes will append the new axes at the end

```
>>> c = Axis('c=c1,c2')
>>> arr.expand(c)
 a  b\c  c1  c2
a1   b1   0   0
a1   b2   1   1
a2   b1   2   2
a2   b2   3   3
```

If you want to new axes to be inserted in a particular order, you have to give that order

```
>>> arr.expand([a, c, b])
 a  c\b  b1  b2
a1   c1   0   1
a1   c2   0   1
a2   c1   2   3
a2   c2   2   3
```

But it is enough to list only the added axes and the axes after them:

```
>>> arr.expand([c, b])
 a  c\b  b1  b2
a1   c1   0   1
a1   c2   0   1
a2   c1   2   3
a2   c2   2   3
```

larray.LArray.prepend

`LArray.prepend`(*self*, *axis*, *value*, *label=None*)

Adds an array before self along an axis.

The two arrays must have compatible axes.

Parameters

axis [axis reference] Axis along which to prepend input array (*value*)

value [scalar or LArray] Scalar or array with compatible axes.

label [str, optional] Label for the new item in axis

Returns

LArray Array expanded with 'value' at the start of 'axis'.

Examples

```
>>> a = ones('nat=BE,FO;sex=M,F')
>>> a
nat\sex    M    F
     BE  1.0  1.0
     FO  1.0  1.0
>>> a.prepend('sex', a.sum('sex'), 'M+F')
nat\sex  M+F    M    F
     BE  2.0  1.0  1.0
     FO  2.0  1.0  1.0
>>> a.prepend('nat', 2, 'Other')
nat\sex    M    F
  Other  2.0  2.0
     BE  1.0  1.0
     FO  1.0  1.0
>>> b = zeros('type=type1,type2')
>>> b
type  type1  type2
        0.0    0.0
>>> a.prepend('sex', b, 'Other')
nat  sex\type  type1  type2
 BE     Other    0.0    0.0
 BE         M    1.0    1.0
 BE         F    1.0    1.0
 FO     Other    0.0    0.0
 FO         M    1.0    1.0
 FO         F    1.0    1.0
```

larray.LArray.append

`LArray.append(self, axis, value, label=None)`

Adds an array to self along an axis.

The two arrays must have compatible axes.

Parameters

axis [axis reference] Axis along which to append *value*.

value [scalar or LArray] Scalar or array with compatible axes.

label [scalar, optional] Label for the new item in axis

Returns

LArray Array expanded with *value* along *axis*.

Examples

```
>>> a = ones('nat=BE,FO;sex=M,F')
>>> a
nat\sex    M    F
     BE  1.0  1.0
     FO  1.0  1.0
>>> a.append('sex', a.sum('sex'), 'M+F')
nat\sex    M    F  M+F
     BE  1.0  1.0  2.0
     FO  1.0  1.0  2.0
>>> a.append('nat', 2, 'Other')
nat\sex    M    F
     BE  1.0  1.0
     FO  1.0  1.0
  Other  2.0  2.0
>>> b = zeros('type=type1,type2')
>>> b
type  type1  type2
        0.0    0.0
>>> a.append('nat', b, 'Other')
  nat  sex\type  type1  type2
   BE         M    1.0    1.0
   BE         F    1.0    1.0
   FO         M    1.0    1.0
   FO         F    1.0    1.0
Other         M    0.0    0.0
Other         F    0.0    0.0
```

larray.LArray.extend

`LArray.extend`(*self*, *axis*, *other*)

Adds an array to self along an axis.

The two arrays must have compatible axes.

Parameters

axis [axis] Axis along which to extend with input array (*other*)

other [LArray] Array with compatible axes

Returns

LArray Array expanded with 'other' along 'axis'.

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> sex2 = Axis('sex=U')
>>> xtype = Axis('type=type1,type2')
>>> arr1 = ones([sex, xtype])
```

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```
>>> arr1
sex\type  type1  type2
       M    1.0    1.0
       F    1.0    1.0
>>> arr2 = zeros([sex2, xtype])
>>> arr2
sex\type  type1  type2
       U    0.0    0.0
>>> arr1.extend('sex', arr2)
sex\type  type1  type2
       M    1.0    1.0
       F    1.0    1.0
       U    0.0    0.0
>>> arr3 = zeros([sex2, nat])
>>> arr3
sex\nat   BE   FO
      U  0.0  0.0
>>> arr1.extend('sex', arr3)
sex  type\nat   BE   FO
  M     type1  1.0  1.0
  M     type2  1.0  1.0
  F     type1  1.0  1.0
  F     type2  1.0  1.0
  U     type1  0.0  0.0
  U     type2  0.0  0.0
```

larray.LArray.insert

`LArray.insert`(*self*, *value*, *before=None*, *after=None*, *pos=None*, *axis=None*, *label=None*)

Inserts value in array along an axis.

Parameters

value [scalar or LArray] Value to insert. If an LArray, it must have compatible axes. If value already has the axis along which it is inserted, *label* should not be used.

before [scalar or Group] Label or group before which to insert *value*.

after [scalar or Group] Label or group after which to insert *value*.

label [str, optional] Label for the new item in axis.

Returns

LArray Array with *value* inserted along *axis*. The dtype of the returned array will be the "closest" type which can hold both the array values and the inserted values without loss of information. For example, when mixing numeric and string types, the dtype will be object.

Examples

```
>>> arr1 = ndtest((2, 3))
>>> arr1
a\b  b0  b1  b2
 a0   0   1   2
```

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```
 a1   3   4   5
>>> arr1.insert(42, before='b1', label='b0.5')
a\b  b0  b0.5  b1  b2
 a0   0    42   1   2
 a1   3    42   4   5
```

The inserted value can be an array:

```
>>> arr2 = ndtest(2)
>>> arr2
a  a0  a1
    0   1
>>> arr1.insert(arr2, after='b0', label='b0.5')
a\b  b0  b0.5  b1  b2
 a0   0     0   1   2
 a1   3     1   4   5
```

If you want to target positions, you have to somehow specify the axis:

```
>>> a, b = arr1.axes
>>> # arr1.insert(42, before='b.i[1]', label='b0.5')
>>> arr1.insert(42, before=b.i[1], label='b0.5')
a\b  b0  b0.5  b1  b2
 a0   0    42   1   2
 a1   3    42   4   5
```

Insert an array which already has the axis

```
>>> arr3 = ndtest('a=a0,a1;b=b0.1,b0.2') + 42
>>> arr3
a\b  b0.1  b0.2
 a0    42    43
 a1    44    45
>>> arr1.insert(arr3, before='b1')
a\b  b0  b0.1  b0.2  b1  b2
 a0   0    42    43   1   2
 a1   3    44    45   4   5
```

larray.LArray.broadcast_with

LArray.**broadcast_with**(*self*, *target*)

Returns an array that is (NumPy) broadcastable with target.

- all common axes must be either of length 1 or the same length
- extra axes in source can have any length and will be moved to the front
- extra axes in target can have any length and the result will have axes of length 1 for those axes

This is different from reshape which ensures the result has exactly the shape of the target.

Parameters

target [LArray or collection of Axis]

Returns

LArray

larray.LArray.align

LArray.**align**(*self*, *other*, *join='outer'*, *fill_value=nan*, *axes=None*)

Align two arrays on their axes with the specified join method.

In other words, it ensure all common axes are compatible. Those arrays can then be used in binary operations.

Parameters

other [LArray-like]

join [{'outer', 'inner', 'left', 'right', 'exact'}, optional]

Join method. For each axis common to both arrays:

- **outer: will use a label if it is in either arrays axis (ordered like the first array).** This is the default as it results in no information loss.
- inner: will use a label if it is in both arrays axis (ordered like the first array).
- left: will use the first array axis labels.
- right: will use the other array axis labels.
- exact: instead of aligning, raise an error when axes to be aligned are not equal.

fill_value [scalar or LArray, optional] Value used to fill cells corresponding to label combinations which are not common to both arrays. Defaults to NaN.

axes [AxisReference or sequence of them, optional] Axes to align. Need to be valid in both arrays. Defaults to None (all common axes). This must be specified when mixing anonymous and non-anonymous axes.

Returns

(left, right) [(LArray, LArray)] Aligned objects

Notes

Arrays with anonymous axes are currently not supported.

Examples

```
>>> arr1 = ndtest((2, 3))
>>> arr1
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> arr2 = -ndtest((3, 2))
>>> # reorder array to make the test more interesting
>>> arr2 = arr2[['b1', 'b0']]
>>> arr2
a\b  b1  b0
 a0  -1   0
 a1  -3  -2
 a2  -5  -4
```

Align arr1 and arr2

```
>>> aligned1, aligned2 = arr1.align(arr2)
>>> aligned1
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  4.0  5.0
 a2  nan  nan  nan
>>> aligned2
a\b    b0    b1   b2
 a0   0.0  -1.0  nan
 a1  -2.0  -3.0  nan
 a2  -4.0  -5.0  nan
```

After aligning all common axes, one can then do operations between the two arrays

```
>>> aligned1 + aligned2
a\b   b0   b1   b2
 a0  0.0  0.0  nan
 a1  1.0  1.0  nan
 a2  nan  nan  nan
```

Other kinds of joins are supported

```
>>> aligned1, aligned2 = arr1.align(arr2, join='inner')
>>> aligned1
a\b   b0   b1
 a0  0.0  1.0
 a1  3.0  4.0
>>> aligned2
a\b    b0    b1
 a0   0.0  -1.0
 a1  -2.0  -3.0
>>> aligned1, aligned2 = arr1.align(arr2, join='left')
>>> aligned1
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  4.0  5.0
>>> aligned2
a\b    b0    b1   b2
 a0   0.0  -1.0  nan
 a1  -2.0  -3.0  nan
>>> aligned1, aligned2 = arr1.align(arr2, join='right')
>>> aligned1
a\b   b1   b0
 a0  1.0  0.0
 a1  4.0  3.0
 a2  nan  nan
>>> aligned2
a\b    b1    b0
 a0  -1.0   0.0
 a1  -3.0  -2.0
 a2  -5.0  -4.0
```

The fill value for missing labels defaults to nan but can be changed to any compatible value.

```
>>> aligned1, aligned2 = arr1.align(arr2, fill_value=0)
>>> aligned1
a\b  b0  b1  b2
```

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```
 a0    0    1    2
 a1    3    4    5
 a2    0    0    0
>>> aligned2
a\b   b0   b1   b2
 a0    0   -1    0
 a1   -2   -3    0
 a2   -4   -5    0
>>> aligned1 + aligned2
a\b   b0   b1   b2
 a0    0    0    2
 a1    1    1    5
 a2   -4   -5    0
```

It also works when either arrays (or both) have extra axes

```
>>> arr3 = ndtest((3, 2, 2))
>>> arr1
a\b   b0   b1   b2
 a0    0    1    2
 a1    3    4    5
>>> arr3
 a   b\c   c0   c1
a0    b0    0    1
a0    b1    2    3
a1    b0    4    5
a1    b1    6    7
a2    b0    8    9
a2    b1   10   11
>>> aligned1, aligned2 = arr1.align(arr3, join='inner')
>>> aligned1
a\b    b0    b1
 a0   0.0   1.0
 a1   3.0   4.0
>>> aligned2
 a   b\c    c0    c1
a0    b0   0.0   1.0
a0    b1   2.0   3.0
a1    b0   4.0   5.0
a1    b1   6.0   7.0
>>> aligned1 + aligned2
 a   b\c     c0     c1
a0    b0    0.0    1.0
a0    b1    3.0    4.0
a1    b0    7.0    8.0
a1    b1   10.0   11.0
```

One can also align only some specific axes (but in that case arrays might not be compatible)

```
>>> aligned1, aligned2 = arr1.align(arr2, axes='b')
>>> aligned1
a\b    b0    b1    b2
 a0   0.0   1.0   2.0
 a1   3.0   4.0   5.0
>>> aligned2
a\b     b0     b1    b2
 a0    0.0   -1.0   nan
```

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```
a1  -2.0  -3.0  nan
a2  -4.0  -5.0  nan
```

Test if two arrays are aligned

```
>>> arr1.align(arr2, join='exact')   # doctest: +NORMALIZE_WHITESPACE
Traceback (most recent call last):
...
ValueError: Both arrays are not aligned because align method with join='exact'
expected Axis(['a0', 'a1'], 'a') to be equal to Axis(['a0', 'a1', 'a2'], 'a')
```

Testing/Searching

LArray.equals(self, other[, rtol, atol, . . .])	Compares self with another array and returns True if they have the same axes and elements, False otherwise.
LArray.eq(self, other[, rtol, atol, nans_equal])	Compares self with another array element-wise and returns an array of booleans.
LArray.isin(self, test_values[, . . .])	Computes whether each element of this array is in *test_values*.
LArray.nonzero(self)	Returns the indices of the elements that are non-zero.
LArray.all(*axes_and_groups[, out, skipna, . . .])	Test whether all selected elements evaluate to True.
LArray.all_by(*axes_and_groups[, out, . . .])	Test whether all selected elements evaluate to True.
LArray.any(*axes_and_groups[, out, skipna, . . .])	Test whether any selected elements evaluate to True.
LArray.any_by(*axes_and_groups[, out, . . .])	Test whether any selected elements evaluate to True.
LArray.min(*axes_and_groups[, out, skipna, . . .])	Get minimum of array elements along given axes/groups.
LArray.min_by(*axes_and_groups[, out, . . .])	Get minimum of array elements for the given axes/groups.
LArray.max(*axes_and_groups[, out, skipna, . . .])	Get maximum of array elements along given axes/groups.
LArray.max_by(*axes_and_groups[, out, . . .])	Get maximum of array elements for the given axes/groups.
LArray.labelofmin(self[, axis])	Returns labels of the minimum values along a given axis.
LArray.indexofmin(self[, axis])	Returns indices of the minimum values along a given axis.
LArray.labelofmax(self[, axis])	Returns labels of the maximum values along a given axis.
LArray.indexofmax(self[, axis])	Returns indices of the maximum values along a given axis.

larray.LArray.equals

LArray.**equals**(*self*, *other*, *rtol=0*, *atol=0*, *nans_equal=False*, *check_axes=False*)

Compares self with another array and returns True if they have the same axes and elements, False otherwise.

Parameters

other [LArray-like] Input array. aslarray() is used on a non-LArray input.

rtol [float or int, optional] The relative tolerance parameter (see Notes). Defaults to 0.

atol [float or int, optional] The absolute tolerance parameter (see Notes). Defaults to 0.

nans_equal [boolean, optional] Whether or not to consider NaN values at the same positions in the two arrays as equal. By default, an array containing NaN values is never equal to another array, even if that other array also contains NaN values at the same positions. The reason is that a NaN value is different from *anything*, including itself. Defaults to False.

check_axes [boolean, optional] Whether or not to check that the set of axes and their order is the same on both sides. Defaults to False. If False, two arrays with compatible axes (and the same data) will compare equal, even if some axis is missing on either side or if the axes are in a different order.

Returns

bool Returns True if self is equal to other.

See also:

LArray.eq

Notes

For finite values, equals uses the following equation to test whether two values are equal:

absolute(array1 - array2) <= (atol + rtol * absolute(array2))

The above equation is not symmetric in array1 and array2, so that array1.equals(array2) might be different from array2.equals(array1) in some rare cases.

Examples

```
>>> arr1 = ndtest((2, 3))
>>> arr1
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> arr2 = arr1.copy()
>>> arr2.equals(arr1)
True
>>> arr2['b1'] += 1
>>> arr2.equals(arr1)
False
>>> arr3 = arr1.set_labels('a', ['x0', 'x1'])
>>> arr3.equals(arr1)
False
```

Test equality between two arrays within a given tolerance range. Return True if absolute(array1 - array2) <= (atol + rtol * absolute(array2)).

```
>>> arr1 = LArray([6., 8.], "a=a0,a1")
>>> arr1
a    a0   a1
   6.0  8.0
>>> arr2 = LArray([5.999, 8.001], "a=a0,a1")
>>> arr2
a      a0     a1
   5.999  8.001
```

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```
>>> arr2.equals(arr1)
False
>>> arr2.equals(arr1, atol=0.01)
True
>>> arr2.equals(arr1, rtol=0.01)
True
```

Arrays with NaN values

```
>>> arr1 = ndtest((2, 3), dtype=float)
>>> arr1['a1', 'b1'] = nan
>>> arr1
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  nan  5.0
>>> arr2 = arr1.copy()
>>> # By default, an array containing NaN values is never equal to another array,
>>> # even if that other array also contains NaN values at the same positions.
>>> # The reason is that a NaN value is different from *anything*, including␣
↪itself.
>>> arr2.equals(arr1)
False
>>> # set flag nans_equal to True to overwrite this behavior
>>> arr2.equals(arr1, nans_equal=True)
True
```

Arrays with the same data but different axes

```
>>> arr1 = ndtest((2, 2))
>>> arr1
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> arr2 = arr1.transpose()
>>> arr2
b\a  a0  a1
 b0   0   2
 b1   1   3
>>> arr2.equals(arr1)
True
>>> arr2.equals(arr1, check_axes=True)
False
>>> arr2 = arr1.expand('c=c0,c1')
>>> arr2
 a  b\c  c0  c1
a0   b0   0   0
a0   b1   1   1
a1   b0   2   2
a1   b1   3   3
>>> arr2.equals(arr1)
True
>>> arr2.equals(arr1, check_axes=True)
False
```

larray.LArray.eq

LArray.**eq**(*self*, *other*, *rtol=0*, *atol=0*, *nans_equal=False*)

Compares self with another array element-wise and returns an array of booleans.

Parameters

other [LArray-like] Input array. aslarray() is used on a non-LArray input.

rtol [float or int, optional] The relative tolerance parameter (see Notes). Defaults to 0.

atol [float or int, optional] The absolute tolerance parameter (see Notes). Defaults to 0.

nans_equal [boolean, optional] Whether or not to consider Nan values at the same positions in the two arrays as equal. By default, an array containing NaN values is never equal to another array, even if that other array also contains NaN values at the same positions. The reason is that a NaN value is different from *anything*, including itself. Defaults to False.

Returns

LArray Boolean array where each cell tells whether corresponding elements of self and other are equal within a tolerance range if given. If nans_equal=True, corresponding elements with NaN values will be considered as equal.

See also:

LArray.equals

Notes

For finite values, eq uses the following equation to test whether two values are equal:

absolute(array1 - array2) <= (atol + rtol * absolute(array2))

The above equation is not symmetric in array1 and array2, so that array1.eq(array2) might be different from array2.eq(array1) in some rare cases.

Examples

```
>>> arr1 = LArray([6., np.nan, 8.], "a=a0..a2")
>>> arr1
a   a0   a1   a2
   6.0  nan  8.0
```

Default behavior (same as == operator)

```
>>> arr1.eq(arr1)
a    a0     a1    a2
   True  False  True
```

Test equality between two arrays within a given tolerance range. Return True if absolute(array1 - array2) <= (atol + rtol * absolute(array2)).

```
>>> arr2 = LArray([5.999, np.nan, 8.001], "a=a0..a2")
>>> arr2
a      a0   a1     a2
   5.999  nan  8.001
```

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```
>>> arr1.eq(arr2, nans_equal=True)
a      a0     a1      a2
   False  True  False
>>> arr1.eq(arr2, atol=0.01, nans_equal=True)
a     a0     a1     a2
   True  True  True
>>> arr1.eq(arr2, rtol=0.01, nans_equal=True)
a     a0     a1     a2
   True  True  True
```

larray.LArray.isin

`LArray.isin(self, test_values, assume_unique=False, invert=False)`

Computes whether each element of this array is in *test_values*. Returns a boolean array of the same shape as this array that is True where the array element is in *test_values* and False otherwise.

Parameters

test_values [array_like or set] The values against which to test each element of this array. If *test_values* is not a 1D array, it will be converted to one.

assume_unique [bool, optional] If True, this array and *test_values* are both assumed to be unique, which can speed up the calculation. Defaults to False.

invert [bool, optional] If True, the values in the returned array are inverted, as if calculating *element not in test_values*. Defaults to False. `isin(a, b, invert=True)` is equivalent to (but faster than) `~isin(a, b)`.

Returns

LArray boolean array of the same shape as this array that is True where the array element is in *test_values* and False otherwise.

Examples

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> arr.isin([1, 5, 7])
a\b     b0     b1     b2
 a0  False   True  False
 a1  False  False   True
>>> arr[arr.isin([1, 5, 7])]
a_b  a0_b1  a1_b2
         1      5
```

larray.LArray.nonzero

`LArray.nonzero(self)`

Returns the indices of the elements that are non-zero.

Specifically, it returns a tuple of arrays (one for each dimension) containing the indices of the non-zero elements in that dimension.

Returns

tuple of arrays [tuple] Indices of elements that are non-zero.

Examples

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> cond = arr > 1
>>> cond
a\b     b0     b1    b2
 a0  False  False  True
 a1   True   True  True
>>> a, b = cond.nonzero()
>>> a
a.i[a_b  a0_b2  a1_b0  a1_b1  a1_b2
             0      1      1      1]
>>> b
b.i[a_b  a0_b2  a1_b0  a1_b1  a1_b2
             2      0      1      2]
>>> # equivalent to arr[cond]
>>> arr[cond.nonzero()]
a_b  a0_b2  a1_b0  a1_b1  a1_b2
         2      3      4      5
```

larray.LArray.all

`LArray.all(*axes_and_groups, out=None, skipna=None, keepaxes=False, **explicit_axes)`

Test whether all selected elements evaluate to True.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the AND reduction is performed. The default (no axis or group) is to perform the AND reduction over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the AND reduction over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string

- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray of bool or bool

See also:

LArray.all_by, *LArray.any*, *LArray.any_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> barr = arr < 6
>>> barr
a\b     b0     b1     b2     b3
 a0   True   True   True   True
 a1   True   True  False  False
 a2  False  False  False  False
 a3  False  False  False  False
>>> barr.all()
False
>>> # along axis 'a'
>>> barr.all('a')
b     b0     b1     b2     b3
   False  False  False  False
>>> # along axis 'b'
>>> barr.all('b')
a     a0     a1     a2     a3
   True  False  False  False
```

Select some rows only

```
>>> barr.all(['a0', 'a1'])
b     b0    b1     b2     b3
   True  True  False  False
>>> # or equivalently
>>> # barr.all('a0,a1')
```

Split an axis in several parts

```
>>> barr.all((['a0', 'a1'], ['a2', 'a3']))
  a\b      b0     b1     b2     b3
a0,a1    True   True  False  False
a2,a3   False  False  False  False
>>> # or equivalently
>>> # barr.all('a0,a1;a2,a3')
```

Same with renaming

```
>>> barr.all((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b      b0     b1     b2     b3
a01    True   True  False  False
a23   False  False  False  False
>>> # or equivalently
>>> # barr.all('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.all_by

`LArray.all_by(*axes_and_groups, out=None, skipna=None, keepaxes=False, **explicit_axes)`
Test whether all selected elements evaluate to True.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The AND reduction is performed along all axes except the given one(s). For groups, AND reduction is performed along groups and non associated axes. The default (no axis or group) is to perform the AND reduction over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the AND reduction over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.

- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray of bool or bool

See also:

LArray.all, *LArray.any*, *LArray.any_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> barr = arr < 6
>>> barr
a\b     b0     b1     b2     b3
 a0   True   True   True   True
 a1   True   True  False  False
 a2  False  False  False  False
 a3  False  False  False  False
>>> barr.all_by()
False
>>> # by axis 'a'
>>> barr.all_by('a')
a     a0     a1     a2     a3
    True  False  False  False
>>> # by axis 'b'
>>> barr.all_by('b')
b      b0     b1     b2     b3
    False  False  False  False
```

Select some rows only

```
>>> barr.all_by(['a0', 'a1'])
False
```

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```
>>> # or equivalently
>>> # barr.all_by('a0,a1')
```

Split an axis in several parts

```
>>> barr.all_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
   False  False
>>> # or equivalently
>>> # barr.all_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> barr.all_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a    a01    a23
   False  False
>>> # or equivalently
>>> # barr.all_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.any

LArray.**any**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Test whether any selected elements evaluate to True.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the OR reduction is performed. The default (no axis or group) is to perform the OR reduction over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the OR reduction over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray of bool or bool

See also:

LArray.any_by, *LArray.all*, *LArray.all_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> barr = arr < 6
>>> barr
a\b     b0     b1     b2     b3
 a0   True   True   True   True
 a1   True   True  False  False
 a2  False  False  False  False
 a3  False  False  False  False
>>> barr.any()
True
>>> # along axis 'a'
>>> barr.any('a')
b     b0     b1     b2     b3
    True   True   True   True
>>> # along axis 'b'
>>> barr.any('b')
a     a0     a1      a2      a3
    True   True   False   False
```

Select some rows only

```
>>> barr.any(['a0', 'a1'])
b     b0     b1     b2     b3
    True   True   True   True
>>> # or equivalently
>>> # barr.any('a0,a1')
```

Split an axis in several parts

```
>>> barr.any((['a0', 'a1'], ['a2', 'a3']))
  a\b     b0     b1     b2     b3
a0,a1   True   True   True   True
a2,a3  False  False  False  False
>>> # or equivalently
>>> # barr.any('a0,a1;a2,a3')
```

Same with renaming

```
>>> barr.any((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b     b0     b1     b2     b3
a01   True   True   True   True
a23  False  False  False  False
>>> # or equivalently
>>> # barr.any('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.any_by

`LArray.any_by`(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Test whether any selected elements evaluate to True.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The OR reduction is performed along all axes except the given one(s). For groups, OR reduction is performed along groups and non associated axes. The default (no axis or group) is to perform the OR reduction over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to perform the OR reduction over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', . . .). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray of bool or bool

See also:

LArray.any, *LArray.all*, *LArray.all_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> barr = arr < 6
>>> barr
a\b     b0     b1     b2     b3
 a0   True   True   True   True
 a1   True   True  False  False
 a2  False  False  False  False
 a3  False  False  False  False
>>> barr.any_by()
True
>>> # by axis 'a'
>>> barr.any_by('a')
a    a0    a1     a2     a3
   True  True  False  False
>>> # by axis 'b'
>>> barr.any_by('b')
b    b0    b1    b2    b3
   True  True  True  True
```

Select some rows only

```
>>> barr.any_by(['a0', 'a1'])
True
>>> # or equivalently
>>> # barr.any_by('a0,a1')
```

Split an axis in several parts

```
>>> barr.any_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
    True  False
>>> # or equivalently
>>> # barr.any_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> barr.any_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a   a01    a23
   True  False
>>> # or equivalently
>>> # barr.any_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.min

LArray.**min**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Get minimum of array elements along given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the minimum is searched. The default (no axis or group) is to search the minimum over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to search the minimum over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.min_by, *LArray.max*, *LArray.max_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.min()
0
>>> # along axis 'a'
>>> arr.min('a')
b  b0  b1  b2  b3
    0   1   2   3
>>> # along axis 'b'
>>> arr.min('b')
a  a0  a1  a2  a3
    0   4   8  12
```

Select some rows only

```
>>> arr.min(['a0', 'a1'])
b  b0  b1  b2  b3
    0   1   2   3
>>> # or equivalently
>>> # arr.min('a0,a1')
```

Split an axis in several parts

```
>>> arr.min((['a0', 'a1'], ['a2', 'a3']))
  a\b  b0  b1  b2  b3
a0,a1   0   1   2   3
a2,a3   8   9  10  11
>>> # or equivalently
>>> # arr.min('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.min((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b  b0  b1  b2  b3
a01   0   1   2   3
a23   8   9  10  11
>>> # or equivalently
>>> # arr.min('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.min_by

LArray.**min_by**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)
Get minimum of array elements for the given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The minimum is searched along all axes except the given one(s). For groups, minimum is searched along groups and non associated axes. The default (no axis or group) is to search the minimum over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to search the minimum over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', ...). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.min, *LArray.max*, *LArray.max_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
```

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```
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.min_by()
0
>>> # along axis 'a'
>>> arr.min_by('a')
a  a0  a1  a2  a3
    0   4   8  12
>>> # along axis 'b'
>>> arr.min_by('b')
b  b0  b1  b2  b3
    0   1   2   3
```

Select some rows only

```
>>> arr.min_by(['a0', 'a1'])
0
>>> # or equivalently
>>> # arr.min_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.min_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
       0      8
>>> # or equivalently
>>> # arr.min_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.min_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a  a01  a23
     0    8
>>> # or equivalently
>>> # arr.min_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.max

`LArray.`**`max`**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)

Get maximum of array elements along given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] Axis(es) or group(s) along which the maximum is searched. The default (no axis or group) is to search the maximum over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).

- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to search the maximum over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- ([‘a1’, ‘a3’, ‘a5’], ‘b1, b3, b5’) : labels separated by commas in a list or a string
- (‘a1:a5:2’) : select labels using a slice (general syntax is ‘start:end:step’ where is ‘step’ is optional and 1 by default).
- (a=’a1, a2, a3’, X.b[‘b1, b2, b3’]) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.
- (‘a1:a3; a5:a7’, b=’b0,b2; b1,b3’) : create several groups with semicolons. Names are simply given by the concatenation of labels (here: ‘a1,a2,a3’, ‘a5,a6,a7’, ‘b0,b2’ and ‘b1,b3’)
- (‘a1:a3 >> a123’, ‘b[b0,b2] >> b12’) : operator ‘ >> ‘ allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0’s and 1.0’s). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. ‘sum’, ‘prod’, . . .). It is possible to override this label by passing a specific value (e.g. keepaxes=’summation’). Defaults to False.

Returns

LArray or scalar

See also:

LArray.max_by, *LArray.min*, *LArray.min_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.max()
15
>>> # along axis 'a'
>>> arr.max('a')
b  b0  b1  b2  b3
   12  13  14  15
>>> # along axis 'b'
>>> arr.max('b')
a  a0  a1  a2  a3
    3   7  11  15
```

Select some rows only

```
>>> arr.max(['a0', 'a1'])
b  b0  b1  b2  b3
    4   5   6   7
>>> # or equivalently
>>> # arr.max('a0,a1')
```

Split an axis in several parts

```
>>> arr.max((['a0', 'a1'], ['a2', 'a3']))
  a\b  b0  b1  b2  b3
a0,a1   4   5   6   7
a2,a3  12  13  14  15
>>> # or equivalently
>>> # arr.max('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.max((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a\b  b0  b1  b2  b3
a01   4   5   6   7
a23  12  13  14  15
>>> # or equivalently
>>> # arr.max('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.max_by

LArray.**max_by**(**axes_and_groups*, *out=None*, *skipna=None*, *keepaxes=False*, ***explicit_axes*)
Get maximum of array elements for the given axes/groups.

Parameters

***axes_and_groups** [None or int or str or Axis or Group or any combination of those] The maximum is searched along all axes except the given one(s). For groups, maximum is searched along groups and non associated axes. The default (no axis or group) is to search the maximum over all the dimensions of the input array.

An axis can be referred by:

- its index (integer). Index can be a negative integer, in which case it counts from the last to the first axis.
- its name (str or AxisReference). You can use either a simple string ('axis_name') or the special variable X (X.axis_name).
- a variable (Axis). If the axis has been defined previously and assigned to a variable, you can pass it as argument.

You may not want to search the maximum over a whole axis but over a selection of specific labels. To do so, you have several possibilities:

- (['a1', 'a3', 'a5'], 'b1, b3, b5') : labels separated by commas in a list or a string
- ('a1:a5:2') : select labels using a slice (general syntax is 'start:end:step' where is 'step' is optional and 1 by default).
- (a='a1, a2, a3', X.b['b1, b2, b3']) : in case of possible ambiguity, i.e. if labels can belong to more than one axis, you must precise the axis.

- ('a1:a3; a5:a7', b='b0,b2; b1,b3') : create several groups with semicolons. Names are simply given by the concatenation of labels (here: 'a1,a2,a3', 'a5,a6,a7', 'b0,b2' and 'b1,b3')
- ('a1:a3 >> a123', 'b[b0,b2] >> b12') : operator ' >> ' allows to rename groups.

out [LArray, optional] Alternate output array in which to place the result. It must have the same shape as the expected output and its type is preserved (e.g., if dtype(out) is float, the result will consist of 0.0's and 1.0's). Axes and labels can be different, only the shape matters. Defaults to None (create a new array).

skipna [bool, optional] Whether or not to skip NaN (null) values. If False, resulting cells will be NaN if any of the aggregated cells is NaN. Defaults to True.

keepaxes [bool or label-like, optional] Whether or not reduced axes are left in the result as dimensions with size one. If True, reduced axes will contain a unique label representing the applied aggregation (e.g. 'sum', 'prod', …). It is possible to override this label by passing a specific value (e.g. keepaxes='summation'). Defaults to False.

Returns

LArray or scalar

See also:

LArray.max, *LArray.min*, *LArray.min_by*

Examples

```
>>> arr = ndtest((4, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
 a3  12  13  14  15
>>> arr.max_by()
15
>>> # along axis 'a'
>>> arr.max_by('a')
a  a0  a1  a2  a3
    3   7  11  15
>>> # along axis 'b'
>>> arr.max_by('b')
b  b0  b1  b2  b3
   12  13  14  15
```

Select some rows only

```
>>> arr.max_by(['a0', 'a1'])
7
>>> # or equivalently
>>> # arr.max_by('a0,a1')
```

Split an axis in several parts

```
>>> arr.max_by((['a0', 'a1'], ['a2', 'a3']))
a  a0,a1  a2,a3
```

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```
       7     15
>>> # or equivalently
>>> # arr.max_by('a0,a1;a2,a3')
```

Same with renaming

```
>>> arr.max_by((X.a['a0', 'a1'] >> 'a01', X.a['a2', 'a3'] >> 'a23'))
a  a01  a23
     7   15
>>> # or equivalently
>>> # arr.max_by('a0,a1>>a01;a2,a3>>a23')
```

larray.LArray.labelofmin

`LArray.labelofmin(self, axis=None)`

Returns labels of the minimum values along a given axis.

Parameters

axis [int or str or Axis, optional] Axis along which to work. If not specified, works on the full array.

Returns

LArray

Notes

In case of multiple occurrences of the minimum values, the indices corresponding to the first occurrence are returned.

Examples

```
>>> nat = Axis('nat=BE,FR,IT')
>>> sex = Axis('sex=M,F')
>>> arr = LArray([[0, 1], [3, 2], [2, 5]], [nat, sex])
>>> arr
nat\sex  M  F
     BE  0  1
     FR  3  2
     IT  2  5
>>> arr.labelofmin('sex')
nat  BE  FR  IT
      M   F   M
>>> arr.labelofmin()
('BE', 'M')
```

larray.LArray.indexofmin

`LArray.indexofmin(self, axis=None)`

Returns indices of the minimum values along a given axis.

Parameters

axis [int or str or Axis, optional] Axis along which to work. If not specified, works on the full array.

Returns

LArray

Notes

In case of multiple occurrences of the minimum values, the indices corresponding to the first occurrence are returned.

Examples

```
>>> nat = Axis('nat=BE,FR,IT')
>>> sex = Axis('sex=M,F')
>>> arr = LArray([[0, 1], [3, 2], [2, 5]], [nat, sex])
>>> arr
nat\sex  M  F
     BE  0  1
     FR  3  2
     IT  2  5
>>> arr.indexofmin('sex')
nat  BE  FR  IT
      0   1   0
>>> arr.indexofmin()
(0, 0)
```

larray.LArray.labelofmax

`LArray.labelofmax(self, axis=None)`

Returns labels of the maximum values along a given axis.

Parameters

axis [int or str or Axis, optional] Axis along which to work. If not specified, works on the full array.

Returns

LArray

Notes

In case of multiple occurrences of the maximum values, the labels corresponding to the first occurrence are returned.

Examples

```
>>> nat = Axis('nat=BE,FR,IT')
>>> sex = Axis('sex=M,F')
>>> arr = LArray([[0, 1], [3, 2], [2, 5]], [nat, sex])
>>> arr
nat\sex  M  F
     BE  0  1
     FR  3  2
     IT  2  5
>>> arr.labelofmax('sex')
nat  BE  FR  IT
      F   M   F
>>> arr.labelofmax()
('IT', 'F')
```

larray.LArray.indexofmax

LArray.**indexofmax**(*self*, *axis=None*)

Returns indices of the maximum values along a given axis.

Parameters

axis [int or str or Axis, optional] Axis along which to work. If not specified, works on the full array.

Returns

LArray

Notes

In case of multiple occurrences of the maximum values, the labels corresponding to the first occurrence are returned.

Examples

```
>>> nat = Axis('nat=BE,FR,IT')
>>> sex = Axis('sex=M,F')
>>> arr = LArray([[0, 1], [3, 2], [2, 5]], [nat, sex])
>>> arr
nat\sex  M  F
     BE  0  1
     FR  3  2
     IT  2  5
>>> arr.indexofmax('sex')
nat  BE  FR  IT
      1   0   1
>>> arr.indexofmax()
(2, 1)
```

Iterating

LArray.keys(self[, axes, ascending])	Returns a view on the array labels along axes.
LArray.values(self[, axes, ascending])	Returns a view on the values of the array along axes.
LArray.items(self[, axes, ascending])	Returns a (label, value) view of the array along axes.

larray.LArray.keys

LArray.**keys**(*self*, *axes=None*, *ascending=True*)

Returns a view on the array labels along axes.

Parameters

axes [int, str or Axis or tuple of them, optional] Axis or axes along which to iterate and in which order. Defaults to None (all axes in the order they are in the array).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

Returns

Sequence An object you can iterate (loop) on and index by position to get the Nth label along axes.

Examples

First, define a small helper function to make the following examples more readable.

```
>>> def str_key(key):
...     return tuple(str(k) for k in key)
```

Then create a test array:

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
```

By default it iterates on all axes, in the order they are in the array.

```
>>> for key in arr.keys():
...     # print both the actual key object, and a (nicer) string representation
...     print(key, "->", str_key(key))
(a.i[0], b.i[0]) -> ('a0', 'b0')
(a.i[0], b.i[1]) -> ('a0', 'b1')
(a.i[1], b.i[0]) -> ('a1', 'b0')
(a.i[1], b.i[1]) -> ('a1', 'b1')
>>> for key in arr.keys(ascending=False):
...     print(str_key(key))
('a1', 'b1')
('a1', 'b0')
('a0', 'b1')
('a0', 'b0')
```

but you can specify another axis order:

```
>>> for key in arr.keys(('b', 'a')):
...     print(str_key(key))
('b0', 'a0')
('b0', 'a1')
('b1', 'a0')
('b1', 'a1')
```

One can specify less axes than the array has:

```
>>> # iterate on the "b" axis, that is return each label along the "b" axis
... for key in arr.keys('b'):
...     print(str_key(key))
('b0',)
('b1',)
```

One can also access elements of the key sequence directly, instead of iterating over it. Say we want to retrieve the first and last keys of our array, we could write:

```
>>> keys = arr.keys()
>>> first_key = keys[0]
>>> str_key(first_key)
('a0', 'b0')
>>> last_key = keys[-1]
>>> str_key(last_key)
('a1', 'b1')
```

larray.LArray.values

LArray.**values**(*self*, *axes=None*, *ascending=True*)
Returns a view on the values of the array along axes.

Parameters

axes [int, str or Axis or tuple of them, optional] Axis or axes along which to iterate and in which order. Defaults to None (all axes in the order they are in the array).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

Returns

Sequence An object you can iterate (loop) on and index by position.

Examples

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
```

By default it iterates on all axes, in the order they are in the array.

```
>>> for value in arr.values():
...     print(value)
```

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```
0
1
2
3
>>> for value in arr.values(ascending=False):
...     print(value)
3
2
1
0
```

but you can specify another axis order:

```
>>> for value in arr.values(('b', 'a')):
...     print(value)
0
2
1
3
```

When you specify less axes than the array has, you get arrays back:

```
>>> # iterate on the "b" axis, that is return the (sub)array for each label along␣
↪the "b" axis
... for value in arr.values('b'):
...     print(value)
a  a0  a1
    0   2
a  a0  a1
    1   3
>>> # iterate on the "b" axis, that is return the (sub)array for each label along␣
↪the "b" axis
... for value in arr.values('b', ascending=False):
...     print(value)
a  a0  a1
    1   3
a  a0  a1
    0   2
```

One can also access elements of the value sequence directly, instead of iterating over it. Say we want to retrieve the first and last values of our array, we could write:

```
>>> values = arr.values()
>>> values[0]
0
>>> values[-1]
3
```

larray.LArray.items

`LArray.items`(*self*, *axes=None*, *ascending=True*)

Returns a (label, value) view of the array along axes.

Parameters

axes [int, str or Axis or tuple of them, optional] Axis or axes along which to iterate and in which order. Defaults to None (all axes in the order they are in the array).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

Returns

Sequence An object you can iterate (loop) on and index by position to get the Nth (label, value) couple along axes.

Examples

First, define a small helper function to make the following examples more readable.

```
>>> def str_key(key):
...     return tuple(str(k) for k in key)
```

Then create a test array:

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
```

By default it iterates on all axes, in the order they are in the array.

```
>>> for key, value in arr.items():
...     print(str_key(key), "->", value)
('a0', 'b0') -> 0
('a0', 'b1') -> 1
('a1', 'b0') -> 2
('a1', 'b1') -> 3
>>> for key, value in arr.items(ascending=False):
...     print(str_key(key), "->", value)
('a1', 'b1') -> 3
('a1', 'b0') -> 2
('a0', 'b1') -> 1
('a0', 'b0') -> 0
```

but you can specify another axis order:

```
>>> for key, value in arr.items(('b', 'a')):
...     print(str_key(key), "->", value)
('b0', 'a0') -> 0
('b0', 'a1') -> 2
('b1', 'a0') -> 1
('b1', 'a1') -> 3
```

When you specify less axes than the array has, you get arrays back:

```
>>> # iterate on the "b" axis, that is return the (sub)array for each label along
↪the "b" axis
... for key, value in arr.items('b'):
...     print(str_key(key), value, sep="\n")
('b0',)
```

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```
a   a0   a1
     0    2
('b1',)
a   a0   a1
     1    3
```

One can also access elements of the items sequence directly, instead of iterating over it. Say we want to retrieve the first and last key-value pairs of our array, we could write:

```
>>> items = arr.items()
>>> first_key, first_value = items[0]
>>> str_key(first_key)
('a0', 'b0')
>>> first_value
0
>>> last_key, last_value = items[-1]
>>> str_key(last_key)
('a1', 'b1')
>>> last_value
3
```

Operators

`@`	Matrix multiplication

Miscellaneous

LArray.divnot0(self, other)	Divides array by other, but returns 0.0 where other is 0.
LArray.clip(self[, minval, maxval, out])	Clip (limit) the values in an array.
LArray.shift(self, axis[, n])	Shifts the cells of the array n-times to the right along axis.
LArray.roll(self[, axis, n])	Rolls the cells of the array n-times to the right along axis.
LArray.diff(self[, axis, d, n, label])	Calculates the n-th order discrete difference along a given axis.
LArray.unique(self[, axes, sort, sep])	Returns unique values (optionally along axes)
LArray.to_clipboard(self, *args, **kwargs)	Sends the content of the array to clipboard.

larray.LArray.divnot0

LArray.**divnot0**(*self*, *other*)

Divides array by other, but returns 0.0 where other is 0.

Parameters

other [scalar or LArray] What to divide by.

Returns

LArray Array divided by other, 0.0 where other is 0

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> a = ndtest((nat, sex))
>>> a
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> b = ndtest(sex)
>>> b
sex  M  F
     0  1
>>> a / b
nat\sex    M    F
     BE  nan  1.0
     FO  inf  3.0
>>> a.divnot0(b)
nat\sex    M    F
     BE  0.0  1.0
     FO  0.0  3.0
```

larray.LArray.clip

LArray.**clip**(*self*, *minval=None*, *maxval=None*, *out=None*)

Clip (limit) the values in an array.

Given an interval, values outside the interval are clipped to the interval bounds. For example, if an interval of [0, 1] is specified, values smaller than 0 become 0, and values larger than 1 become 1.

Parameters

minval [scalar or array-like, optional] Minimum value. If None, clipping is not performed on lower bound. Defaults to None.

maxval [scalar or array-like, optional] Maximum value. If None, clipping is not performed on upper bound. Defaults to None.

out [LArray, optional] The results will be placed in this array.

Returns

LArray An array with the elements of the current array, but where values < *minval* are replaced with *minval*, and those > *maxval* with *maxval*.

Notes

- At least either *minval* or *maxval* must be defined.
- If *minval* and/or *maxval* are array_like, broadcast will occur between self, *minval* and *maxval*.

Examples

```
>>> arr = ndtest((3, 3)) - 3
>>> arr
a\b  b0  b1  b2
 a0  -3  -2  -1
 a1   0   1   2
 a2   3   4   5
>>> arr.clip(0, 2)
a\b  b0  b1  b2
 a0   0   0   0
 a1   0   1   2
 a2   2   2   2
```

Clipping on lower bound only

```
>>> arr.clip(0)
a\b  b0  b1  b2
 a0   0   0   0
 a1   0   1   2
 a2   3   4   5
```

Clipping on upper bound only

```
>>> arr.clip(maxval=2)
a\b  b0  b1  b2
 a0  -3  -2  -1
 a1   0   1   2
 a2   2   2   2
```

larray.LArray.shift

LArray.**shift**(*self*, *axis*, *n=1*)

Shifts the cells of the array n-times to the right along axis.

Parameters

axis [int, str or Axis] Axis for which we want to perform the shift.

n [int, optional] Number of cells to shift. Defaults to 1.

Returns

LArray

See also:

LArray.roll cells which are pushed "outside of the axis" are reintroduced on the opposite side of the axis instead of being dropped.

Examples

```
>>> arr = ndtest('sex=M,F;year=2019..2021')
>>> arr
sex\year  2019  2020  2021
       M     0     1     2
       F     3     4     5
>>> arr.shift('year')
```

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```
sex\year  2020  2021
       M     0     1
       F     3     4
>>> arr.shift('year', n=-1)
sex\year  2019  2020
       M     1     2
       F     4     5
```

larray.LArray.roll

`LArray.roll(self, axis=None, n=1)`

Rolls the cells of the array n-times to the right along axis. Cells which would be pushed "outside of the axis" are reintroduced on the opposite side of the axis.

Parameters

axis [int, str or Axis, optional] Axis along which to roll. Defaults to None (all axes).

n [int or LArray, optional] Number of positions to roll. Defaults to 1. Use a negative integers to roll left. If n is an LArray the number of positions rolled can vary along the axes of n.

Returns

LArray

See also:

LArray.shift cells which are pushed "outside of the axis" are dropped instead of being reintroduced on the opposite side of the axis.

Examples

```
>>> arr = ndtest('sex=M,F;year=2019..2021')
>>> arr
sex\year  2019  2020  2021
       M     0     1     2
       F     3     4     5
>>> arr.roll('year')
sex\year  2019  2020  2021
       M     2     0     1
       F     5     3     4
```

One can also roll by a different amount depending on another axis

```
>>> # let us roll by 1 for men and by 2 for women
>>> n = sequence(arr.sex, initial=1)
>>> n
sex  M  F
     1  2
>>> arr.roll('year', n)
sex\year  2019  2020  2021
       M     2     0     1
       F     4     5     3
```

larray.LArray.diff

LArray.**diff**(*self*, *axis=-1*, *d=1*, *n=1*, *label='upper'*)

Calculates the n-th order discrete difference along a given axis.

The first order difference is given by out[n] = a[n + 1] - a[n] along the given axis, higher order differences are calculated by using diff recursively.

Parameters

axis [int, str, Group or Axis, optional] Axis or group along which the difference is taken. Defaults to the last axis.

d [int, optional] Periods to shift for forming difference. Defaults to 1.

n [int, optional] The number of times values are differenced. Defaults to 1.

label [{'lower', 'upper'}, optional] The new labels in *axis* will have the labels of either the array being subtracted ('lower') or the array it is subtracted from ('upper'). Defaults to 'upper'.

Returns

LArray The n-th order differences. The shape of the output is the same as *a* except for *axis* which is smaller by *n* * *d*.

Examples

```
>>> a = ndtest('sex=M,F;type=type1,type2,type3').cumsum('type')
>>> a
sex\type  type1  type2  type3
       M      0      1      3
       F      3      7     12
>>> a.diff()
sex\type  type2  type3
       M      1      2
       F      4      5
>>> a.diff(n=2)
sex\type  type3
       M      1
       F      1
>>> a.diff('sex')
sex\type  type1  type2  type3
       F      3      6      9
>>> a.diff(a.type['type2':])
sex\type  type3
       M      2
       F      5
```

larray.LArray.unique

LArray.**unique**(*self*, *axes=None*, *sort=False*, *sep='_'*)

Returns unique values (optionally along axes)

Parameters

axes [axis reference (int, str, Axis) or sequence of them, optional] Axis or axes along which to compute unique values. Defaults to None (all axes).

sort [bool, optional] Whether or not to sort unique values. Defaults to False. Sorting is not implemented yet for unique() along multiple axes.

sep [str, optional] Separator when several labels need to be combined. Defaults to '_'.

Returns

LArray array with unique values

Examples

```
>>> arr = LArray([[0, 2, 0, 0],
...               [1, 1, 1, 0]], 'a=a0,a1;b=b0..b3')
>>> arr
a\b  b0  b1  b2  b3
 a0   0   2   0   0
 a1   1   1   1   0
```

By default unique() returns the first occurrence of each unique value in the order it appears:

```
>>> arr.unique()
a_b  a0_b0  a0_b1  a1_b0
         0      2      1
```

To sort the unique values, use the sort argument:

```
>>> arr.unique(sort=True)
a_b  a0_b0  a1_b0  a0_b1
         0      1      2
```

One can also compute unique sub-arrays (i.e. combination of values) along axes. In our example the a0=0, a1=1 combination appears twice along the 'b' axis, so 'b2' is not returned:

```
>>> arr.unique('b')
a\b  b0  b1  b3
 a0   0   2   0
 a1   1   1   0
>>> arr.unique('b', sort=True)
a\b  b3  b0  b1
 a0   0   0   2
 a1   0   1   1
```

larray.LArray.to_clipboard

LArray.**to_clipboard**(*self*, **args*, ***kwargs*)

Sends the content of the array to clipboard.

Using to_clipboard() makes it possible to paste the content of the array into a file (Excel, ascii file,…).

Examples

```
>>> a = ndtest('nat=BE,FO;sex=M,F')
>>> a.to_clipboard()  # doctest: +SKIP
```

Converting to Pandas objects

LArray.to_series(self[, name, dropna])	Converts LArray into Pandas Series.
LArray.to_frame(self[, fold_last_axis_name, . . .])	Converts LArray into Pandas DataFrame.

larray.LArray.to_series

LArray.**to_series**(*self*, *name=None*, *dropna=False*)

Converts LArray into Pandas Series.

Parameters

name [str, optional] Name of the series. Defaults to None.

dropna [bool, optional.] False by default.

Returns

Pandas Series

Notes

Since pandas does not provide a way to handle metadata (yet), all metadata associated with the array will be lost.

Examples

```
>>> arr = ndtest((2, 3), dtype=float)
>>> arr
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  4.0  5.0
>>> arr.to_series() # doctest: +NORMALIZE_WHITESPACE
a   b
a0  b0    0.0
    b1    1.0
    b2    2.0
a1  b0    3.0
    b1    4.0
    b2    5.0
dtype: float64
```

Set a name

```
>>> arr.to_series('my_name') # doctest: +NORMALIZE_WHITESPACE
        a   b
a0  b0    0.0
    b1    1.0
    b2    2.0
a1  b0    3.0
    b1    4.0
    b2    5.0
Name: my_name, dtype: float64
```

Drop NaN values

```
>>> arr['b1'] = nan
>>> arr
a\b   b0   b1   b2
 a0  0.0  nan  2.0
 a1  3.0  nan  5.0
>>> arr.to_series(dropna=True) # doctest: +NORMALIZE_WHITESPACE
a   b
a0  b0    0.0
    b2    2.0
a1  b0    3.0
    b2    5.0
dtype: float64
```

larray.LArray.to_frame

LArray.**to_frame**(*self*, *fold_last_axis_name=False*, *dropna=None*)

Converts LArray into Pandas DataFrame.

Parameters

fold_last_axis_name [bool, optional] Defaults to False.

dropna [{'any', 'all', None}, optional]

- any : if any NA values are present, drop that label
- all : if all values are NA, drop that label
- None by default.

Returns

Pandas DataFrame

Notes

Since pandas does not provide a way to handle metadata (yet), all metadata associated with the array will be lost.

Examples

```
>>> arr = ndtest((2, 2, 2))
>>> arr
 a  b\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
>>> arr.to_frame()                                                    #␣
↪doctest: +NORMALIZE_WHITESPACE
c       c0  c1
a  b
a0 b0    0   1
   b1    2   3
a1 b0    4   5
   b1    6   7
```

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```
>>> arr.to_frame(fold_last_axis_name=True)                                    #␣
↪doctest: +NORMALIZE_WHITESPACE
        c0  c1
a  b\c
a0 b0    0   1
   b1    2   3
a1 b0    4   5
   b1    6   7
```

Plotting

LArray.plot	Plots the data of the array into a graph (window pop-up).

larray.LArray.plot

property LArray.**plot**

Plots the data of the array into a graph (window pop-up).

The graph can be tweaked to achieve the desired formatting and can be saved to a .png file.

Parameters

kind [str]

- 'line' : line plot (default)
- 'bar' : vertical bar plot
- 'barh' : horizontal bar plot
- 'hist' : histogram
- 'box' : boxplot
- 'kde' : Kernel Density Estimation plot
- 'density' : same as 'kde'
- 'area' : area plot
- 'pie' : pie plot
- 'scatter' : scatter plot (if array's dimensions >= 2)
- 'hexbin' : hexbin plot (if array's dimensions >= 2)

ax [matplotlib axes object, default None]

subplots [boolean, default False] Make separate subplots for each column

sharex [boolean, default True if ax is None else False] In case subplots=True, share x axis and set some x axis labels to invisible; defaults to True if ax is None otherwise False if an ax is passed in; Be aware, that passing in both an ax and sharex=True will alter all x axis labels for all axis in a figure!

sharey [boolean, default False] In case subplots=True, share y axis and set some y axis labels to invisible

layout [tuple (optional)] (rows, columns) for the layout of subplots

figsize [a tuple (width, height) in inches]

use_index [boolean, default True] Use index as ticks for x axis

title [string] Title to use for the plot

grid [boolean, default None (matlab style default)] Axis grid lines

legend [False/True/'reverse'] Place legend on axis subplots

style [list or dict] matplotlib line style per column

logx [boolean, default False] Use log scaling on x axis

logy [boolean, default False] Use log scaling on y axis

loglog [boolean, default False] Use log scaling on both x and y axes

xticks [sequence] Values to use for the xticks

yticks [sequence] Values to use for the yticks

xlim [2-tuple/list]

ylim [2-tuple/list]

rot [int, default None] Rotation for ticks (xticks for vertical, yticks for horizontal plots)

fontsize [int, default None] Font size for xticks and yticks

colormap [str or matplotlib colormap object, default None] Colormap to select colors from. If string, load colormap with that name from matplotlib.

colorbar [boolean, optional] If True, plot colorbar (only relevant for 'scatter' and 'hexbin' plots)

position [float] Specify relative alignments for bar plot layout. From 0 (left/bottom-end) to 1 (right/top-end). Default is 0.5 (center)

layout [tuple (optional)] (rows, columns) for the layout of the plot

yerr [array-like] Error bars on y axis

xerr [array-like] Error bars on x axis

stacked [boolean, default False in line and bar plots, and True in area plot.] If True, create stacked plot.

****kwargs** [keywords] Options to pass to matplotlib plotting method

Returns

axes [matplotlib.AxesSubplot or np.array of them]

Notes

See Pandas documentation of *plot* function for more details on this subject

Examples

```
>>> import matplotlib.pyplot as plt # doctest: +SKIP
>>> a = ndtest('sex=M,F;age=0..20')
```

Simple line plot

```
>>> a.plot() # doctest: +SKIP
>>> # shows figure (reset the current figure after showing it! Do not call it␣
↪before savefig)
>>> plt.show() # doctest: +SKIP
```

Line plot with grid, title and both axes in logscale

```
>>> a.plot(grid=True, loglog=True, title='line plot') # doctest: +SKIP
>>> # saves figure in a file (see matplotlib.pyplot.savefig documentation for␣
↪more details)
>>> plt.savefig('my_file.png') # doctest: +SKIP
```

2 bar plots sharing the same x axis (one for males and one for females)

```
>>> a.plot.bar(subplots=True, sharex=True) # doctest: +SKIP
>>> plt.show() # doctest: +SKIP
```

Create a figure containing 2 x 2 graphs

```
>>> # see matplotlib.pyplot.subplots documentation for more details
>>> fig, ax = plt.subplots(2, 2, figsize=(15, 15)) # doctest: +SKIP
>>> # 2 curves : Males and Females
>>> a.plot(ax=ax[0, 0], title='line plot') # doctest: +SKIP
>>> # bar plot with stacked values
>>> a.plot.bar(ax=ax[0, 1], stacked=True, title='stacked bar plot') # doctest:␣
↪+SKIP
>>> # same as previously but with colored areas instead of bars
>>> a.plot.area(ax=ax[1, 0], title='area plot') # doctest: +SKIP
>>> # scatter plot
>>> a.plot.scatter(ax=ax[1, 1], x='M', y='F', title='scatter plot') # doctest:␣
↪+SKIP
>>> plt.show() # doctest: +SKIP
```

4.3.6 Utility Functions

- *Miscellaneous*
- *Rounding*
- *Exponents And Logarithms*
- *Trigonometric functions*
- *Hyperbolic functions*
- *Complex Numbers*
- *Floating Point Routines*

Miscellaneous

`where`(condition, x, y)	Return elements, either from *x* or *y*, depending on *condition*.
`maximum`(x1, x2[, out, dtype])	Element-wise maximum of array elements.
`minimum`(x1, x2[, out, dtype])	Element-wise minimum of array elements.

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`inverse`(*args, **kwargs)	Compute the (multiplicative) inverse of a matrix.
`interp`(*args, **kwargs)	One-dimensional linear interpolation.
`convolve`(*args, **kwargs)	Returns the discrete, linear convolution of two one-dimensional sequences.
`absolute`(x, /[, out, where, casting, order, ...])	Calculate the absolute value element-wise.
`fabs`(x, /[, out, where, casting, order, ...])	Compute the absolute values element-wise.
`isnan`(x, /[, out, where, casting, order, ...])	Test element-wise for NaN and return result as a boolean array.
`isinf`(x, /[, out, where, casting, order, ...])	Test element-wise for positive or negative infinity.
`nan_to_num`(*args, **kwargs)	Replace NaN with zero and infinity with large finite numbers (default behaviour) or with the numbers defined by the user using the *nan*, *posinf* and/or *neginf* keywords.
`sqrt`(x, /[, out, where, casting, order, ...])	Return the non-negative square-root of an array, element-wise.
`i0`(*args, **kwargs)	Modified Bessel function of the first kind, order 0.
`sinc`(*args, **kwargs)	Return the sinc function.

larray.where

`larray.where(condition, x, y)`

Return elements, either from *x* or *y*, depending on *condition*.

Parameters

condition [boolean LArray] When True, yield *x*, otherwise yield *y*.

x, y [LArray] Values from which to choose.

Returns

out [LArray] If both *x* and *y* are specified, the output array contains elements of *x* where *condition* is True, and elements from *y* elsewhere.

Examples

```
>>> from larray import LArray
>>> arr = LArray([[10, 7, 5, 9],
...               [5, 8, 3, 7],
...               [6, 2, 0, 9],
...               [9, 10, 5, 6]], "a=a0..a3;b=b0..b3")
>>> arr
a\b  b0  b1  b2  b3
 a0  10   7   5   9
 a1   5   8   3   7
 a2   6   2   0   9
 a3   9  10   5   6
```

Simple use

```
>>> where(arr <= 5, 0, arr)
a\b  b0  b1  b2  b3
 a0  10   7   0   9
 a1   0   8   0   7
```

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```
a2    6    0    0    9
a3    9   10    0    6
```

With broadcasting

```
>>> mean_by_col = arr.mean('a')
>>> mean_by_col
b   b0    b1    b2    b3
   7.5  6.75  3.25  7.75
>>> # for each column, set values below the mean value to the mean value
>>> where(arr < mean_by_col, mean_by_col, arr)
a\b    b0    b1    b2    b3
 a0  10.0   7.0   5.0   9.0
 a1   7.5   8.0  3.25  7.75
 a2   7.5  6.75  3.25   9.0
 a3   9.0  10.0   5.0  7.75
```

larray.maximum

`larray.maximum`(*x1*, *x2*, *out=None*, *dtype=None*)

Element-wise maximum of array elements.

Compare two arrays and returns a new array containing the element-wise maxima. If one of the elements being compared is a NaN, then that element is returned. If both elements are NaNs then the first is returned. The latter distinction is important for complex NaNs, which are defined as at least one of the real or imaginary parts being a NaN. The net effect is that NaNs are propagated.

Parameters

x1, x2 [LArray] The arrays holding the elements to be compared.

out [LArray, optional] An array into which the result is stored.

dtype [data-type, optional] Overrides the dtype of the output array.

Returns

y [LArray or scalar] The maximum of *x1* and *x2*, element-wise. This is a scalar if both *x1* and *x2* are scalars.

See also:

minimum Element-wise minimum of two arrays, propagates NaNs.

Notes

The maximum is equivalent to `where(x1 >= x2, x1, x2)` when neither x1 nor x2 are NaNs, but it is faster.

Examples

```
>>> from larray import LArray
>>> arr1 = LArray([[10, 7, 5, 9],
...                [5, 8, 3, 7]], "a=a0,a1;b=b0..b3")
```

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```
>>> arr2 = LArray([[6, 2, 9, 0],
...                [9, 10, 5, 6]], "a=a0,a1;b=b0..b3")
>>> arr1
a\b  b0  b1  b2  b3
 a0  10   7   5   9
 a1   5   8   3   7
>>> arr2
a\b  b0  b1  b2  b3
 a0   6   2   9   0
 a1   9  10   5   6
```

```
>>> maximum(arr1, arr2)
a\b  b0  b1  b2  b3
 a0  10   7   9   9
 a1   9  10   5   7
```

With broadcasting

```
>>> arr2['a0']
b  b0  b1  b2  b3
    6   2   9   0
>>> maximum(arr1, arr2['a0'])
a\b  b0  b1  b2  b3
 a0  10   7   9   9
 a1   6   8   9   7
```

larray.minimum

`larray.minimum`(*x1*, *x2*, *out=None*, *dtype=None*)

Element-wise minimum of array elements.

Compare two arrays and returns a new array containing the element-wise minima. If one of the elements being compared is a NaN, then that element is returned. If both elements are NaNs then the first is returned. The latter distinction is important for complex NaNs, which are defined as at least one of the real or imaginary parts being a NaN. The net effect is that NaNs are propagated.

Parameters

x1, x2 [LArray] The arrays holding the elements to be compared.

out [LArray, optional] An array into which the result is stored.

dtype [data-type, optional] Overrides the dtype of the output array.

Returns

y [LArray or scalar] The minimum of *x1* and *x2*, element-wise. This is a scalar if both *x1* and *x2* are scalars.

See also:

`maximum` Element-wise maximum of two arrays, propagates NaNs.

Notes

The minimum is equivalent to `where(x1 <= x2, x1, x2)` when neither x1 nor x2 are NaNs, but it is faster.

Examples

```
>>> from larray import LArray
>>> arr1 = LArray([[10, 7, 5, 9],
...                [5, 8, 3, 7]], "a=a0,a1;b=b0..b3")
>>> arr2 = LArray([[6, 2, 9, 0],
...                [9, 10, 5, 6]], "a=a0,a1;b=b0..b3")
>>> arr1
a\b  b0  b1  b2  b3
 a0  10   7   5   9
 a1   5   8   3   7
>>> arr2
a\b  b0  b1  b2  b3
 a0   6   2   9   0
 a1   9  10   5   6
```

```
>>> minimum(arr1, arr2)
a\b  b0  b1  b2  b3
 a0   6   2   5   0
 a1   5   8   3   6
```

With broadcasting

```
>>> arr2['a0']
b  b0  b1  b2  b3
    6   2   9   0
>>> minimum(arr1, arr2['a0'])
a\b  b0  b1  b2  b3
 a0   6   2   5   0
 a1   5   2   3   0
```

larray.inverse

`larray.`**`inverse`**`(`**args*, ***kwargs*`)`

Compute the (multiplicative) inverse of a matrix.

larray specific variant of `numpy.inv`.

Documentation from numpy:

Given a square matrix *a*, return the matrix *ainv* satisfying `dot(a, ainv) = dot(ainv, a) = eye(a.shape[0])`.

Parameters

a [(..., M, M) array_like] Matrix to be inverted.

Returns

ainv [(..., M, M) ndarray or matrix] (Multiplicative) inverse of the matrix *a*.

Raises

LinAlgError If *a* is not square or inversion fails.

Notes

New in version 1.8.0.

Broadcasting rules apply, see the *numpy.linalg* documentation for details.

Examples

```
>>> from numpy.linalg import inv
>>> a = np.array([[1., 2.], [3., 4.]])
>>> ainv = inv(a)
>>> np.allclose(np.dot(a, ainv), np.eye(2))
True
>>> np.allclose(np.dot(ainv, a), np.eye(2))
True
```

If a is a matrix object, then the return value is a matrix as well:

```
>>> ainv = inv(np.matrix(a))
>>> ainv
matrix([[-2. ,  1. ],
        [ 1.5, -0.5]])
```

Inverses of several matrices can be computed at once:

```
>>> a = np.array([[[1., 2.], [3., 4.]], [[1, 3], [3, 5]]])
>>> inv(a)
array([[[-2.  ,  1.  ],
        [ 1.5 , -0.5 ]],
       [[-1.25,  0.75],
        [ 0.75, -0.25]]])
```

larray.interp

`larray.interp(*args, **kwargs)`

One-dimensional linear interpolation.

larray specific variant of `numpy.interp`.

Documentation from numpy:

Returns the one-dimensional piecewise linear interpolant to a function with given discrete data points (*xp*, *fp*), evaluated at *x*.

Parameters

x [array_like] The x-coordinates at which to evaluate the interpolated values.

xp [1-D sequence of floats] The x-coordinates of the data points, must be increasing if argument *period* is not specified. Otherwise, *xp* is internally sorted after normalizing the periodic boundaries with `xp = xp % period`.

fp [1-D sequence of float or complex] The y-coordinates of the data points, same length as *xp*.

left [optional float or complex corresponding to fp] Value to return for *x < xp[0]*, default is *fp[0]*.

right [optional float or complex corresponding to fp] Value to return for *x > xp[-1]*, default is *fp[-1]*.

period [None or float, optional] A period for the x-coordinates. This parameter allows the proper interpolation of angular x-coordinates. Parameters *left* and *right* are ignored if *period* is specified.

New in version 1.10.0.

Returns

y [float or complex (corresponding to fp) or ndarray] The interpolated values, same shape as *x*.

Raises

ValueError If *xp* and *fp* have different length If *xp* or *fp* are not 1-D sequences If *period* == *0*

Notes

Does not check that the x-coordinate sequence *xp* is increasing. If *xp* is not increasing, the results are nonsense. A simple check for increasing is:

```
np.all(np.diff(xp) > 0)
```

Examples

```
>>> xp = [1, 2, 3]
>>> fp = [3, 2, 0]
>>> np.interp(2.5, xp, fp)
1.0
>>> np.interp([0, 1, 1.5, 2.72, 3.14], xp, fp)
array([3.  , 3.  , 2.5 , 0.56, 0.  ])
>>> UNDEF = -99.0
>>> np.interp(3.14, xp, fp, right=UNDEF)
-99.0
```

Plot an interpolant to the sine function:

```
>>> x = np.linspace(0, 2*np.pi, 10)
>>> y = np.sin(x)
>>> xvals = np.linspace(0, 2*np.pi, 50)
>>> yinterp = np.interp(xvals, x, y)
>>> import matplotlib.pyplot as plt
>>> plt.plot(x, y, 'o')
[<matplotlib.lines.Line2D object at 0x...>]
>>> plt.plot(xvals, yinterp, '-x')
[<matplotlib.lines.Line2D object at 0x...>]
>>> plt.show()
```

Interpolation with periodic x-coordinates:

```
>>> x = [-180, -170, -185, 185, -10, -5, 0, 365]
>>> xp = [190, -190, 350, -350]
>>> fp = [5, 10, 3, 4]
>>> np.interp(x, xp, fp, period=360)
array([7.5 , 5.  , 8.75, 6.25, 3.  , 3.25, 3.5 , 3.75])
```

Complex interpolation:

```
>>> x = [1.5, 4.0]
>>> xp = [2,3,5]
>>> fp = [1.0j, 0, 2+3j]
>>> np.interp(x, xp, fp)
array([0.+1.j , 1.+1.5j])
```

larray.convolve

larray.**convolve**(**args*, ***kwargs*)

Returns the discrete, linear convolution of two one-dimensional sequences.

larray specific variant of `numpy.convolve`.

Documentation from numpy:

The convolution operator is often seen in signal processing, where it models the effect of a linear time-invariant system on a signal [1]. In probability theory, the sum of two independent random variables is distributed according to the convolution of their individual distributions.

If *v* is longer than *a*, the arrays are swapped before computation.

Parameters

a [(N,) array_like] First one-dimensional input array.

v [(M,) array_like] Second one-dimensional input array.

mode [{'full', 'valid', 'same'}, optional]

'full': By default, mode is 'full'. This returns the convolution at each point of overlap, with an output shape of (N+M-1,). At the end-points of the convolution, the signals do not overlap completely, and boundary effects may be seen.

'same': Mode 'same' returns output of length `max(M, N)`. Boundary effects are still visible.

'valid': Mode 'valid' returns output of length `max(M, N) - min(M, N) + 1`. The convolution product is only given for points where the signals overlap completely. Values outside the signal boundary have no effect.

Returns

out [ndarray] Discrete, linear convolution of *a* and *v*.

See also:

`scipy.signal.fftconvolve` Convolve two arrays using the Fast Fourier Transform.

`scipy.linalg.toeplitz` Used to construct the convolution operator.

`polymul` Polynomial multiplication. Same output as convolve, but also accepts poly1d objects as input.

Notes

The discrete convolution operation is defined as

$$(a * v)[n] = \sum_{m=-\infty}^{\infty} a[m]v[n-m]$$

It can be shown that a convolution $x(t) * y(t)$ in time/space is equivalent to the multiplication $X(f)Y(f)$ in the Fourier domain, after appropriate padding (padding is necessary to prevent circular convolution). Since multiplication is more efficient (faster) than convolution, the function *scipy.signal.fftconvolve* exploits the FFT to calculate the convolution of large data-sets.

References

[1]

Examples

Note how the convolution operator flips the second array before "sliding" the two across one another:

```
>>> np.convolve([1, 2, 3], [0, 1, 0.5])
array([0. , 1. , 2.5, 4. , 1.5])
```

Only return the middle values of the convolution. Contains boundary effects, where zeros are taken into account:

```
>>> np.convolve([1,2,3],[0,1,0.5], 'same')
array([1. ,  2.5,  4. ])
```

The two arrays are of the same length, so there is only one position where they completely overlap:

```
>>> np.convolve([1,2,3],[0,1,0.5], 'valid')
array([2.5])
```

larray.absolute

`larray.`**`absolute`**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Calculate the absolute value element-wise.

larray specific variant of `numpy.absolute`.

Documentation from numpy:

`np.abs` is a shorthand for this function.

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

absolute [ndarray] An ndarray containing the absolute value of each element in *x*. For complex input, `a + ib`, the absolute value is $\sqrt{a^2 + b^2}$. This is a scalar if *x* is a scalar.

Examples

```
>>> x = np.array([-1.2, 1.2])
>>> np.absolute(x)
array([ 1.2,  1.2])
>>> np.absolute(1.2 + 1j)
1.5620499351813308
```

Plot the function over `[-10, 10]`:

```
>>> import matplotlib.pyplot as plt
```

```
>>> x = np.linspace(start=-10, stop=10, num=101)
>>> plt.plot(x, np.absolute(x))
>>> plt.show()
```

Plot the function over the complex plane:

```
>>> xx = x + 1j * x[:, np.newaxis]
>>> plt.imshow(np.abs(xx), extent=[-10, 10, -10, 10], cmap='gray')
>>> plt.show()
```

larray.fabs

`larray.fabs`(*x*, */*, *out=None*, *, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Compute the absolute values element-wise.

larray specific variant of `numpy.fabs`.

Documentation from numpy:

This function returns the absolute values (positive magnitude) of the data in *x*. Complex values are not handled, use *absolute* to find the absolute values of complex data.

Parameters

x [array_like] The array of numbers for which the absolute values are required. If *x* is a scalar, the result *y* will also be a scalar.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray or scalar] The absolute values of *x*, the returned values are always floats. This is a scalar if *x* is a scalar.

See also:

`absolute` Absolute values including *complex* types.

Examples

```
>>> np.fabs(-1)
1.0
>>> np.fabs([-1.2, 1.2])
array([ 1.2,  1.2])
```

larray.isnan

`larray.isnan`(*x*, */*, *out=None*, *, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Test element-wise for NaN and return result as a boolean array.

larray specific variant of `numpy.isnan`.

Documentation from numpy:

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray or bool] True where `x` is NaN, false otherwise. This is a scalar if *x* is a scalar.

See also:

`isinf`, `isneginf`, `isposinf`, `isfinite`, `isnat`

Notes

NumPy uses the IEEE Standard for Binary Floating-Point for Arithmetic (IEEE 754). This means that Not a Number is not equivalent to infinity.

Examples

```
>>> np.isnan(np.nan)
True
>>> np.isnan(np.inf)
False
>>> np.isnan([np.log(-1.),1.,np.log(0)])
array([ True, False, False])
```

larray.isinf

`larray.isinf`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Test element-wise for positive or negative infinity.

larray specific variant of `numpy.isinf`.

Documentation from numpy:

Returns a boolean array of the same shape as *x*, True where `x == +/-inf`, otherwise False.

Parameters

x [array_like] Input values

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [bool (scalar) or boolean ndarray] True where `x` is positive or negative infinity, false otherwise. This is a scalar if *x* is a scalar.

See also:

isneginf, **isposinf**, ***isnan***, **isfinite**

Notes

NumPy uses the IEEE Standard for Binary Floating-Point for Arithmetic (IEEE 754).

Errors result if the second argument is supplied when the first argument is a scalar, or if the first and second arguments have different shapes.

Examples

```
>>> np.isinf(np.inf)
True
>>> np.isinf(np.nan)
False
>>> np.isinf(np.NINF)
True
>>> np.isinf([np.inf, -np.inf, 1.0, np.nan])
array([ True,  True, False, False])
```

```
>>> x = np.array([-np.inf, 0., np.inf])
>>> y = np.array([2, 2, 2])
>>> np.isinf(x, y)
array([1, 0, 1])
>>> y
array([1, 0, 1])
```

larray.nan_to_num

`larray.nan_to_num(*args, **kwargs)`

Replace NaN with zero and infinity with large finite numbers (default behaviour) or with the numbers defined by the user using the *nan*, *posinf* and/or *neginf* keywords.

larray specific variant of `numpy.nan_to_num`.

Documentation from numpy:

If *x* is inexact, NaN is replaced by zero or by the user defined value in *nan* keyword, infinity is replaced by the largest finite floating point values representable by `x.dtype` or by the user defined value in *posinf* keyword and -infinity is replaced by the most negative finite floating point values representable by `x.dtype` or by the user defined value in *neginf* keyword.

For complex dtypes, the above is applied to each of the real and imaginary components of *x* separately.

If *x* is not inexact, then no replacements are made.

Parameters

x [scalar or array_like] Input data.

copy [bool, optional] Whether to create a copy of *x* (True) or to replace values in-place (False). The in-place operation only occurs if casting to an array does not require a copy. Default is True.

nan [int, float, optional] Value to be used to fill NaN values. If no value is passed then NaN values will be replaced with 0.0.

posinf [int, float, optional] Value to be used to fill positive infinity values. If no value is passed then positive infinity values will be replaced with a very large number.

neginf [int, float, optional] Value to be used to fill negative infinity values. If no value is passed then negative infinity values will be replaced with a very small (or negative) number.

New in version 1.13.

Returns

out [ndarray] *x*, with the non-finite values replaced. If *copy* is False, this may be *x* itself.

See also:

isinf Shows which elements are positive or negative infinity.

isneginf Shows which elements are negative infinity.

isposinf Shows which elements are positive infinity.

isnan Shows which elements are Not a Number (NaN).

isfinite Shows which elements are finite (not NaN, not infinity)

Notes

NumPy uses the IEEE Standard for Binary Floating-Point for Arithmetic (IEEE 754). This means that Not a Number is not equivalent to infinity.

Examples

```
>>> np.nan_to_num(np.inf)
1.7976931348623157e+308
>>> np.nan_to_num(-np.inf)
-1.7976931348623157e+308
>>> np.nan_to_num(np.nan)
0.0
>>> x = np.array([np.inf, -np.inf, np.nan, -128, 128])
>>> np.nan_to_num(x)
array([ 1.79769313e+308, -1.79769313e+308,  0.00000000e+000, # may vary
       -1.28000000e+002,  1.28000000e+002])
>>> np.nan_to_num(x, nan=-9999, posinf=33333333, neginf=33333333)
array([ 3.3333333e+07,  3.3333333e+07, -9.9990000e+03,
       -1.2800000e+02,  1.2800000e+02])
>>> y = np.array([complex(np.inf, np.nan), np.nan, complex(np.nan, np.inf)])
array([  1.79769313e+308,  -1.79769313e+308,   0.00000000e+000, # may vary
     -1.28000000e+002,   1.28000000e+002])
>>> np.nan_to_num(y)
array([  1.79769313e+308 +0.00000000e+000j, # may vary
         0.00000000e+000 +0.00000000e+000j,
         0.00000000e+000 +1.79769313e+308j])
>>> np.nan_to_num(y, nan=111111, posinf=222222)
array([222222.+111111.j, 111111.     +0.j, 111111.+222222.j])
```

larray.sqrt

larray.**sqrt** (*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Return the non-negative square-root of an array, element-wise.

larray specific variant of `numpy.sqrt`.

Documentation from numpy:

Parameters

x [array_like] The values whose square-roots are required.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] An array of the same shape as *x*, containing the positive square-root of each element in *x*. If any element in *x* is complex, a complex array is returned (and the square-roots of negative reals are calculated). If all of the elements in *x* are real, so is *y*, with negative elements returning `nan`. If *out* was provided, *y* is a reference to it. This is a scalar if *x* is a scalar.

See also:

`lib.scimath.sqrt` A version which returns complex numbers when given negative reals.

Notes

sqrt has–consistent with common convention–as its branch cut the real "interval" [*-inf*, 0), and is continuous from above on it. A branch cut is a curve in the complex plane across which a given complex function fails to be continuous.

Examples

```
>>> np.sqrt([1,4,9])
array([ 1.,  2.,  3.])
```

```
>>> np.sqrt([4, -1, -3+4J])
array([ 2.+0.j,  0.+1.j,  1.+2.j])
```

```
>>> np.sqrt([4, -1, np.inf])
array([ 2., nan, inf])
```

larray.i0

`larray.i0(*args, **kwargs)`

Modified Bessel function of the first kind, order 0.

larray specific variant of `numpy.i0`.

Documentation from numpy:

Usually denoted I_0. This function does broadcast, but will *not* "up-cast" int dtype arguments unless accompanied by at least one float or complex dtype argument (see Raises below).

Parameters

x [array_like, dtype float or complex] Argument of the Bessel function.

Returns

out [ndarray, shape = x.shape, dtype = x.dtype] The modified Bessel function evaluated at each of the elements of *x*.

Raises

TypeError: array cannot be safely cast to required type If argument consists exclusively of int dtypes.

See also:

scipy.special.i0, **scipy.special.iv**, **scipy.special.ive**

Notes

The scipy implementation is recommended over this function: it is a proper ufunc written in C, and more than an order of magnitude faster.

We use the algorithm published by Clenshaw [1] and referenced by Abramowitz and Stegun [2], for which the function domain is partitioned into the two intervals [0,8] and (8,inf), and Chebyshev polynomial expansions are employed in each interval. Relative error on the domain [0,30] using IEEE arithmetic is documented [3] as having a peak of 5.8e-16 with an rms of 1.4e-16 (n = 30000).

References

[1], [2], [3]

Examples

```
>>> np.i0(0.)
array(1.0)  # may vary
>>> np.i0([0., 1. + 2j])
array([ 1.00000000+0.j        ,  0.18785373+0.64616944j])  # may vary
```

larray.sinc

larray.**sinc**(**args*, ***kwargs*)

Return the sinc function.

larray specific variant of `numpy.sinc`.

Documentation from numpy:

The sinc function is $\sin(\pi x)/(\pi x)$.

Parameters

x [ndarray] Array (possibly multi-dimensional) of values for which to to calculate `sinc(x)`.

Returns

out [ndarray] `sinc(x)`, which has the same shape as the input.

Notes

`sinc(0)` is the limit value 1.

The name sinc is short for "sine cardinal" or "sinus cardinalis".

The sinc function is used in various signal processing applications, including in anti-aliasing, in the construction of a Lanczos resampling filter, and in interpolation.

For bandlimited interpolation of discrete-time signals, the ideal interpolation kernel is proportional to the sinc function.

References

[1], [2]

Examples

```
>>> import matplotlib.pyplot as plt
>>> x = np.linspace(-4, 4, 41)
>>> np.sinc(x)
 array([-3.89804309e-17,  -4.92362781e-02,  -8.40918587e-02, # may vary
        -8.90384387e-02,  -5.84680802e-02,   3.89804309e-17,
        6.68206631e-02,   1.16434881e-01,   1.26137788e-01,
        8.50444803e-02,  -3.89804309e-17,  -1.03943254e-01,
        -1.89206682e-01,  -2.16236208e-01,  -1.55914881e-01,
        3.89804309e-17,   2.33872321e-01,   5.04551152e-01,
        7.56826729e-01,   9.35489284e-01,   1.00000000e+00,
        9.35489284e-01,   7.56826729e-01,   5.04551152e-01,
        2.33872321e-01,   3.89804309e-17,  -1.55914881e-01,
       -2.16236208e-01,  -1.89206682e-01,  -1.03943254e-01,
       -3.89804309e-17,   8.50444803e-02,   1.26137788e-01,
        1.16434881e-01,   6.68206631e-02,   3.89804309e-17,
        -5.84680802e-02,  -8.90384387e-02,  -8.40918587e-02,
        -4.92362781e-02,  -3.89804309e-17])
```

```
>>> plt.plot(x, np.sinc(x))
[<matplotlib.lines.Line2D object at 0x...>]
>>> plt.title("Sinc Function")
Text(0.5, 1.0, 'Sinc Function')
>>> plt.ylabel("Amplitude")
Text(0, 0.5, 'Amplitude')
>>> plt.xlabel("X")
Text(0.5, 0, 'X')
>>> plt.show()
```

It works in 2-D as well:

```
>>> x = np.linspace(-4, 4, 401)
>>> xx = np.outer(x, x)
>>> plt.imshow(np.sinc(xx))
<matplotlib.image.AxesImage object at 0x...>
```

Rounding

round(*args, **kwargs)	Round an array to the given number of decimals.
floor(x, /[, out, where, casting, order, . . .])	Return the floor of the input, element-wise.
ceil(x, /[, out, where, casting, order, . . .])	Return the ceiling of the input, element-wise.
trunc(x, /[, out, where, casting, order, . . .])	Return the truncated value of the input, element-wise.
rint(x, /[, out, where, casting, order, . . .])	Round elements of the array to the nearest integer.
fix(*args, **kwargs)	Round to nearest integer towards zero.

larray.round

larray.**round**(**args*, ***kwargs*)

Round an array to the given number of decimals.

larray specific variant of `numpy.round_`.

Documentation from numpy:

See also:

around equivalent function; see for details.

larray.floor

larray.**floor**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Return the floor of the input, element-wise.

larray specific variant of `numpy.floor`.

Documentation from numpy:

The floor of the scalar *x* is the largest integer *i*, such that *i* <= *x*. It is often denoted as $\lfloor x \rfloor$.

Parameters

x [array_like] Input data.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray or scalar] The floor of each element in *x*. This is a scalar if *x* is a scalar.

See also:

ceil, *trunc*, *rint*

Notes

Some spreadsheet programs calculate the "floor-towards-zero", in other words `floor(-2.5) == -2`. NumPy instead uses the definition of *floor* where *floor(-2.5) == -3*.

Examples

```
>>> a = np.array([-1.7, -1.5, -0.2, 0.2, 1.5, 1.7, 2.0])
>>> np.floor(a)
array([-2., -2., -1.,  0.,  1.,  1.,  2.])
```

larray.ceil

`larray.ceil`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Return the ceiling of the input, element-wise.

larray specific variant of `numpy.ceil`.

Documentation from numpy:

The ceil of the scalar *x* is the smallest integer *i*, such that *i* >= *x*. It is often denoted as $\lceil x \rceil$.

Parameters

x [array_like] Input data.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray or scalar] The ceiling of each element in *x*, with *float* dtype. This is a scalar if *x* is a scalar.

See also:

floor, *trunc*, *rint*

Examples

```
>>> a = np.array([-1.7, -1.5, -0.2, 0.2, 1.5, 1.7, 2.0])
>>> np.ceil(a)
array([-1., -1., -0.,  1.,  2.,  2.,  2.])
```

larray.trunc

`larray.trunc(x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True[, signature, extobj])`

Return the truncated value of the input, element-wise.

larray specific variant of `numpy.trunc`.

Documentation from numpy:

The truncated value of the scalar *x* is the nearest integer *i* which is closer to zero than *x* is. In short, the fractional part of the signed number *x* is discarded.

Parameters

x [array_like] Input data.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray or scalar] The truncated value of each element in *x*. This is a scalar if *x* is a scalar.

See also:

ceil, *floor*, *rint*

Notes

New in version 1.3.0.

Examples

```
>>> a = np.array([-1.7, -1.5, -0.2, 0.2, 1.5, 1.7, 2.0])
>>> np.trunc(a)
array([-1., -1., -0.,  0.,  1.,  1.,  2.])
```

larray.rint

`larray.rint(x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True[, signature, extobj])`

Round elements of the array to the nearest integer.

larray specific variant of `numpy.rint`.

Documentation from numpy:

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Output array is same shape and type as *x*. This is a scalar if *x* is a scalar.

See also:

ceil, *floor*, *trunc*

Examples

```
>>> a = np.array([-1.7, -1.5, -0.2, 0.2, 1.5, 1.7, 2.0])
>>> np.rint(a)
array([-2., -2., -0.,  0.,  2.,  2.,  2.])
```

larray.fix

`larray.fix(*args, **kwargs)`

Round to nearest integer towards zero.

larray specific variant of `numpy.fix`.

Documentation from numpy:

Round an array of floats element-wise to nearest integer towards zero. The rounded values are returned as floats.

Parameters

x [array_like] An array of floats to be rounded

y [ndarray, optional] Output array

Returns

out [ndarray of floats] The array of rounded numbers

See also:

trunc, *floor*, *ceil*

around Round to given number of decimals

Examples

```
>>> np.fix(3.14)
3.0
>>> np.fix(3)
3.0
>>> np.fix([2.1, 2.9, -2.1, -2.9])
array([ 2.,  2., -2., -2.])
```

Exponents And Logarithms

exp(x, /[, out, where, casting, order, . . .])	Calculate the exponential of all elements in the input array.
expm1(x, /[, out, where, casting, order, . . .])	Calculate `exp(x) - 1` for all elements in the array.
exp2(x, /[, out, where, casting, order, . . .])	Calculate *2**p* for all *p* in the input array.
log(x, /[, out, where, casting, order, . . .])	Natural logarithm, element-wise.
log10(x, /[, out, where, casting, order, . . .])	Return the base 10 logarithm of the input array, element-wise.
log2(x, /[, out, where, casting, order, . . .])	Base-2 logarithm of *x*.
log1p(x, /[, out, where, casting, order, . . .])	Return the natural logarithm of one plus the input array, element-wise.
logaddexp(x1, x2, /[, out, where, casting, . . .])	Logarithm of the sum of exponentiations of the inputs.
logaddexp2(x1, x2, /[, out, where, casting, . . .])	Logarithm of the sum of exponentiations of the inputs in base-2.

larray.exp

larray.**exp**(*x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True*[, *signature, extobj*])

Calculate the exponential of all elements in the input array.

larray specific variant of `numpy.exp`.

Documentation from numpy:

Parameters

x [array_like] Input values.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Output array, element-wise exponential of *x*. This is a scalar if *x* is a scalar.

See also:

expm1 Calculate `exp(x) - 1` for all elements in the array.

exp2 Calculate `2**x` for all elements in the array.

Notes

The irrational number `e` is also known as Euler's number. It is approximately 2.718281, and is the base of the natural logarithm, `ln` (this means that, if $x = \ln y = \log_e y$, then $e^x = y$. For real input, `exp(x)` is always positive.

For complex arguments, `x = a + ib`, we can write $e^x = e^a e^{ib}$. The first term, e^a, is already known (it is the real argument, described above). The second term, e^{ib}, is $\cos b + i \sin b$, a function with magnitude 1 and a periodic phase.

References

[1], [2]

Examples

Plot the magnitude and phase of `exp(x)` in the complex plane:

```
>>> import matplotlib.pyplot as plt
```

```
>>> x = np.linspace(-2*np.pi, 2*np.pi, 100)
>>> xx = x + 1j * x[:, np.newaxis] # a + ib over complex plane
>>> out = np.exp(xx)
```

```
>>> plt.subplot(121)
>>> plt.imshow(np.abs(out),
...            extent=[-2*np.pi, 2*np.pi, -2*np.pi, 2*np.pi], cmap='gray')
>>> plt.title('Magnitude of exp(x)')
```

```
>>> plt.subplot(122)
>>> plt.imshow(np.angle(out),
...            extent=[-2*np.pi, 2*np.pi, -2*np.pi, 2*np.pi], cmap='hsv')
>>> plt.title('Phase (angle) of exp(x)')
>>> plt.show()
```

larray.expm1

`larray.`**`expm1`**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Calculate `exp(x) - 1` for all elements in the array.

larray specific variant of `numpy.expm1`.

Documentation from numpy:

Parameters

x [array_like] Input values.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Element-wise exponential minus one: `out = exp(x) - 1`. This is a scalar if *x* is a scalar.

See also:

log1p `log(1 + x)`, the inverse of expm1.

Notes

This function provides greater precision than `exp(x) - 1` for small values of `x`.

Examples

The true value of `exp(1e-10) - 1` is `1.00000000005e-10` to about 32 significant digits. This example shows the superiority of expm1 in this case.

```
>>> np.expm1(1e-10)
1.00000000005e-10
>>> np.exp(1e-10) - 1
1.000000082740371e-10
```

larray.exp2

`larray.exp2(x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True[, signature, extobj])`

Calculate *2**p* for all *p* in the input array.

larray specific variant of `numpy.exp2`.

Documentation from numpy:

Parameters

x [array_like] Input values.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Element-wise 2 to the power *x*. This is a scalar if *x* is a scalar.

See also:

`power`

Notes

New in version 1.3.0.

Examples

```
>>> np.exp2([2, 3])
array([ 4.,  8.])
```

larray.log

`larray.log`(*x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True*[, *signature, extobj*])

Natural logarithm, element-wise.

larray specific variant of `numpy.log`.

Documentation from numpy:

The natural logarithm *log* is the inverse of the exponential function, so that *log(exp(x))* = *x*. The natural logarithm is logarithm in base *e*.

Parameters

x [array_like] Input value.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The natural logarithm of *x*, element-wise. This is a scalar if *x* is a scalar.

See also:

log10, *log2*, *log1p*, **emath.log**

Notes

Logarithm is a multivalued function: for each *x* there is an infinite number of *z* such that *exp(z) = x*. The convention is to return the *z* whose imaginary part lies in *[-pi, pi]*.

For real-valued input data types, *log* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *log* is a complex analytical function that has a branch cut *[-inf, 0]* and is continuous from above on it. *log* handles the floating-point negative zero as an infinitesimal negative number, conforming to the C99 standard.

References

[1], [2]

Examples

```
>>> np.log([1, np.e, np.e**2, 0])
array([  0.,   1.,   2., -Inf])
```

larray.log10

`larray.log10`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Return the base 10 logarithm of the input array, element-wise.

larray specific variant of `numpy.log10`.

Documentation from numpy:

Parameters

x [array_like] Input values.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The logarithm to the base 10 of *x*, element-wise. NaNs are returned where x is negative. This is a scalar if *x* is a scalar.

See also:

emath.log10

Notes

Logarithm is a multivalued function: for each *x* there is an infinite number of *z* such that *10**z = x*. The convention is to return the *z* whose imaginary part lies in *[-pi, pi]*.

For real-valued input data types, *log10* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *log10* is a complex analytical function that has a branch cut *[-inf, 0]* and is continuous from above on it. *log10* handles the floating-point negative zero as an infinitesimal negative number, conforming to the C99 standard.

References

[1], [2]

Examples

```
>>> np.log10([1e-15, -3.])
array([-15.,  nan])
```

larray.log2

larray.**log2**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Base-2 logarithm of *x*.

larray specific variant of `numpy.log2`.

Documentation from numpy:

Parameters

x [array_like] Input values.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] Base-2 logarithm of *x*. This is a scalar if *x* is a scalar.

See also:

log, *log10*, *log1p*, **emath.log2**

Notes

New in version 1.3.0.

Logarithm is a multivalued function: for each *x* there is an infinite number of *z* such that *2**z = x*. The convention is to return the *z* whose imaginary part lies in *[-pi, pi]*.

For real-valued input data types, *log2* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *log2* is a complex analytical function that has a branch cut *[-inf, 0]* and is continuous from above on it. *log2* handles the floating-point negative zero as an infinitesimal negative number, conforming to the C99 standard.

Examples

```
>>> x = np.array([0, 1, 2, 2**4])
>>> np.log2(x)
array([-Inf,   0.,   1.,   4.])
```

```
>>> xi = np.array([0+1.j, 1, 2+0.j, 4.j])
>>> np.log2(xi)
array([ 0.+2.26618007j,  0.+0.j        ,  1.+0.j        ,  2.+2.26618007j])
```

larray.log1p

larray.**log1p**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Return the natural logarithm of one plus the input array, element-wise.

larray specific variant of `numpy.log1p`.

Documentation from numpy:

Calculates `log(1 + x)`.

Parameters

x [array_like] Input values.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] Natural logarithm of *1 + x*, element-wise. This is a scalar if *x* is a scalar.

See also:

expm1 `exp(x) - 1`, the inverse of *log1p*.

Notes

For real-valued input, *log1p* is accurate also for *x* so small that *1 + x == 1* in floating-point accuracy.

Logarithm is a multivalued function: for each *x* there is an infinite number of *z* such that *exp(z) = 1 + x*. The convention is to return the *z* whose imaginary part lies in *[-pi, pi]*.

For real-valued input data types, *log1p* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *log1p* is a complex analytical function that has a branch cut *[-inf, -1]* and is continuous from above on it. *log1p* handles the floating-point negative zero as an infinitesimal negative number, conforming to the C99 standard.

References

[1], [2]

Examples

```
>>> np.log1p(1e-99)
1e-99
>>> np.log(1 + 1e-99)
0.0
```

larray.logaddexp

`larray.`**`logaddexp`**(*x1*, *x2*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Logarithm of the sum of exponentiations of the inputs.

larray specific variant of `numpy.logaddexp`.

Documentation from numpy:

Calculates `log(exp(x1) + exp(x2))`. This function is useful in statistics where the calculated probabilities of events may be so small as to exceed the range of normal floating point numbers. In such cases the logarithm of the calculated probability is stored. This function allows adding probabilities stored in such a fashion.

Parameters

x1, x2 [array_like] Input values. If `x1.shape != x2.shape`, they must be broadcastable to a common shape (which becomes the shape of the output).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

result [ndarray] Logarithm of `exp(x1) + exp(x2)`. This is a scalar if both *x1* and *x2* are scalars.

See also:

`logaddexp2` Logarithm of the sum of exponentiations of inputs in base 2.

Notes

New in version 1.3.0.

Examples

```
>>> prob1 = np.log(1e-50)
>>> prob2 = np.log(2.5e-50)
>>> prob12 = np.logaddexp(prob1, prob2)
>>> prob12
-113.87649168120691
>>> np.exp(prob12)
3.5000000000000057e-50
```

larray.logaddexp2

`larray.`**`logaddexp2`**(*x1*, *x2*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Logarithm of the sum of exponentiations of the inputs in base-2.

larray specific variant of `numpy.logaddexp2`.

Documentation from numpy:

Calculates `log2(2**x1 + 2**x2)`. This function is useful in machine learning when the calculated probabilities of events may be so small as to exceed the range of normal floating point numbers. In such cases the base-2 logarithm of the calculated probability can be used instead. This function allows adding probabilities stored in such a fashion.

Parameters

x1, x2 [array_like] Input values. If `x1.shape != x2.shape`, they must be broadcastable to a common shape (which becomes the shape of the output).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

result [ndarray] Base-2 logarithm of `2**x1 + 2**x2`. This is a scalar if both *x1* and *x2* are scalars.

See also:

`logaddexp` Logarithm of the sum of exponentiations of the inputs.

Notes

New in version 1.3.0.

Examples

```
>>> prob1 = np.log2(1e-50)
>>> prob2 = np.log2(2.5e-50)
>>> prob12 = np.logaddexp2(prob1, prob2)
>>> prob1, prob2, prob12
(-166.09640474436813, -164.77447664948076, -164.28904982231052)
>>> 2**prob12
3.4999999999999914e-50
```

Trigonometric functions

`sin`(x, /[, out, where, casting, order, …])	Trigonometric sine, element-wise.
`cos`(x, /[, out, where, casting, order, …])	Cosine element-wise.
`tan`(x, /[, out, where, casting, order, …])	Compute tangent element-wise.
`arcsin`(x, /[, out, where, casting, order, …])	Inverse sine, element-wise.
`arccos`(x, /[, out, where, casting, order, …])	Trigonometric inverse cosine, element-wise.
`arctan`(x, /[, out, where, casting, order, …])	Trigonometric inverse tangent, element-wise.
`hypot`(x1, x2, /[, out, where, casting, …])	Given the “legs” of a right triangle, return its hypotenuse.
`arctan2`(x1, x2, /[, out, where, casting, …])	Element-wise arc tangent of `x1/x2` choosing the quadrant correctly.
`degrees`(x, /[, out, where, casting, order, …])	Convert angles from radians to degrees.
`radians`(x, /[, out, where, casting, order, …])	Convert angles from degrees to radians.
`unwrap`(*args, **kwargs)	Unwrap by changing deltas between values to 2*pi complement.

larray.sin

`larray.sin`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Trigonometric sine, element-wise.

larray specific variant of `numpy.sin`.

Documentation from numpy:

Parameters

x [array_like] Angle, in radians (2π rad equals 360 degrees).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [array_like] The sine of each element of x. This is a scalar if *x* is a scalar.

See also:

arcsin, ***sinh***, ***cos***

Notes

The sine is one of the fundamental functions of trigonometry (the mathematical study of triangles). Consider a circle of radius 1 centered on the origin. A ray comes in from the $+x$ axis, makes an angle at the origin (measured counter-clockwise from that axis), and departs from the origin. The y coordinate of the outgoing ray's intersection with the unit circle is the sine of that angle. It ranges from -1 for $x = 3\pi/2$ to +1 for $\pi/2$. The function has zeroes where the angle is a multiple of π. Sines of angles between π and 2π are negative. The numerous properties of the sine and related functions are included in any standard trigonometry text.

Examples

Print sine of one angle:

```
>>> np.sin(np.pi/2.)
1.0
```

Print sines of an array of angles given in degrees:

```
>>> np.sin(np.array((0., 30., 45., 60., 90.)) * np.pi / 180. )
array([ 0.        ,  0.5       ,  0.70710678,  0.8660254 ,  1.        ])
```

Plot the sine function:

```
>>> import matplotlib.pylab as plt
>>> x = np.linspace(-np.pi, np.pi, 201)
>>> plt.plot(x, np.sin(x))
>>> plt.xlabel('Angle [rad]')
>>> plt.ylabel('sin(x)')
>>> plt.axis('tight')
>>> plt.show()
```

larray.cos

larray.**cos**(*x*, */*, *out=None*, *, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Cosine element-wise.

larray specific variant of `numpy.cos`.

Documentation from numpy:

Parameters

x [array_like] Input array in radians.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The corresponding cosine values. This is a scalar if *x* is a scalar.

Notes

If *out* is provided, the function writes the result into it, and returns a reference to *out*. (See Examples)

References

M. Abramowitz and I. A. Stegun, Handbook of Mathematical Functions. New York, NY: Dover, 1972.

Examples

```
>>> np.cos(np.array([0, np.pi/2, np.pi]))
array([  1.00000000e+00,   6.12303177e-17,  -1.00000000e+00])
>>>
>>> # Example of providing the optional output parameter
>>> out1 = np.array([0], dtype='d')
```

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```
>>> out2 = np.cos([0.1], out1)
>>> out2 is out1
True
>>>
>>> # Example of ValueError due to provision of shape mis-matched `out`
>>> np.cos(np.zeros((3,3)),np.zeros((2,2)))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operands could not be broadcast together with shapes (3,3) (2,2)
```

larray.tan

larray.**tan**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Compute tangent element-wise.

larray specific variant of `numpy.tan`.

Documentation from numpy:

Equivalent to `np.sin(x)/np.cos(x)` element-wise.

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The corresponding tangent values. This is a scalar if *x* is a scalar.

Notes

If *out* is provided, the function writes the result into it, and returns a reference to *out*. (See Examples)

References

M. Abramowitz and I. A. Stegun, Handbook of Mathematical Functions. New York, NY: Dover, 1972.

Examples

```
>>> from math import pi
>>> np.tan(np.array([-pi,pi/2,pi]))
array([  1.22460635e-16,   1.63317787e+16,  -1.22460635e-16])
>>>
>>> # Example of providing the optional output parameter illustrating
>>> # that what is returned is a reference to said parameter
>>> out1 = np.array([0], dtype='d')
>>> out2 = np.cos([0.1], out1)
>>> out2 is out1
True
>>>
>>> # Example of ValueError due to provision of shape mis-matched `out`
>>> np.cos(np.zeros((3,3)),np.zeros((2,2)))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operands could not be broadcast together with shapes (3,3) (2,2)
```

larray.arcsin

larray.**arcsin**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Inverse sine, element-wise.

larray specific variant of `numpy.arcsin`.

Documentation from numpy:

Parameters

x [array_like] *y*-coordinate on the unit circle.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

angle [ndarray] The inverse sine of each element in *x*, in radians and in the closed interval `[-pi/2, pi/2]`. This is a scalar if *x* is a scalar.

See also:

sin, *cos*, *arccos*, *tan*, *arctan*, *arctan2*, **emath.arcsin**

Notes

arcsin is a multivalued function: for each *x* there are infinitely many numbers *z* such that $sin(z) = x$. The convention is to return the angle *z* whose real part lies in [-pi/2, pi/2].

For real-valued input data types, *arcsin* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *arcsin* is a complex analytic function that has, by convention, the branch cuts [-inf, -1] and [1, inf] and is continuous from above on the former and from below on the latter.

The inverse sine is also known as *asin* or sin^{-1}.

References

Abramowitz, M. and Stegun, I. A., *Handbook of Mathematical Functions*, 10th printing, New York: Dover, 1964, pp. 79ff. http://www.math.sfu.ca/~cbm/aands/

Examples

```
>>> np.arcsin(1)     # pi/2
1.5707963267948966
>>> np.arcsin(-1)    # -pi/2
-1.5707963267948966
>>> np.arcsin(0)
0.0
```

larray.arccos

`larray.arccos`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Trigonometric inverse cosine, element-wise.

larray specific variant of `numpy.arccos`.

Documentation from numpy:

The inverse of *cos* so that, if `y = cos(x)`, then `x = arccos(y)`.

Parameters

x [array_like] *x*-coordinate on the unit circle. For real arguments, the domain is [-1, 1].

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

angle [ndarray] The angle of the ray intersecting the unit circle at the given *x*-coordinate in radians [0, pi]. This is a scalar if *x* is a scalar.

See also:

`cos`, `arctan`, `arcsin`, `emath.arccos`

Notes

arccos is a multivalued function: for each *x* there are infinitely many numbers *z* such that *cos(z) = x*. The convention is to return the angle *z* whose real part lies in *[0, pi]*.

For real-valued input data types, *arccos* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *arccos* is a complex analytic function that has branch cuts *[-inf, -1]* and *[1, inf]* and is continuous from above on the former and from below on the latter.

The inverse *cos* is also known as *acos* or cos^-1.

References

M. Abramowitz and I.A. Stegun, "Handbook of Mathematical Functions", 10th printing, 1964, pp. 79. http://www.math.sfu.ca/~cbm/aands/

Examples

We expect the arccos of 1 to be 0, and of -1 to be pi:

```
>>> np.arccos([1, -1])
array([ 0.        ,  3.14159265])
```

Plot arccos:

```
>>> import matplotlib.pyplot as plt
>>> x = np.linspace(-1, 1, num=100)
>>> plt.plot(x, np.arccos(x))
>>> plt.axis('tight')
>>> plt.show()
```

larray.arctan

`larray.arctan`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Trigonometric inverse tangent, element-wise.

larray specific variant of `numpy.arctan`.

Documentation from numpy:

The inverse of tan, so that if `y = tan(x)` then `x = arctan(y)`.

Parameters

x [array_like]

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Out has the same shape as *x*. Its real part is in `[-pi/2, pi/2]` (`arctan(+/-inf)` returns `+/-pi/2`). This is a scalar if *x* is a scalar.

See also:

arctan2 The "four quadrant" arctan of the angle formed by (*x*, *y*) and the positive *x*-axis.

angle Argument of complex values.

Notes

arctan is a multi-valued function: for each *x* there are infinitely many numbers *z* such that tan(*z*) = *x*. The convention is to return the angle *z* whose real part lies in [-pi/2, pi/2].

For real-valued input data types, *arctan* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *arctan* is a complex analytic function that has [*1j, infj*] and [*-1j, -infj*] as branch cuts, and is continuous from the left on the former and from the right on the latter.

The inverse tangent is also known as *atan* or tan^{-1}.

References

Abramowitz, M. and Stegun, I. A., *Handbook of Mathematical Functions*, 10th printing, New York: Dover, 1964, pp. 79. http://www.math.sfu.ca/~cbm/aands/

Examples

We expect the arctan of 0 to be 0, and of 1 to be pi/4:

```
>>> np.arctan([0, 1])
array([ 0.        ,  0.78539816])
```

```
>>> np.pi/4
0.78539816339744828
```

Plot arctan:

```
>>> import matplotlib.pyplot as plt
>>> x = np.linspace(-10, 10)
>>> plt.plot(x, np.arctan(x))
>>> plt.axis('tight')
>>> plt.show()
```

larray.hypot

larray.**hypot**(*x1*, *x2*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Given the "legs" of a right triangle, return its hypotenuse.

larray specific variant of `numpy.hypot`.

Documentation from numpy:

Equivalent to `sqrt(x1**2 + x2**2)`, element-wise. If *x1* or *x2* is scalar_like (i.e., unambiguously cast-able to a scalar type), it is broadcast for use with each element of the other argument. (See Examples)

Parameters

x1, x2 [array_like] Leg of the triangle(s). If `x1.shape != x2.shape`, they must be broadcastable to a common shape (which becomes the shape of the output).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

z [ndarray] The hypotenuse of the triangle(s). This is a scalar if both *x1* and *x2* are scalars.

Examples

```
>>> np.hypot(3*np.ones((3, 3)), 4*np.ones((3, 3)))
array([[ 5.,  5.,  5.],
       [ 5.,  5.,  5.],
       [ 5.,  5.,  5.]])
```

Example showing broadcast of scalar_like argument:

```
>>> np.hypot(3*np.ones((3, 3)), [4])
array([[ 5.,  5.,  5.],
       [ 5.,  5.,  5.],
       [ 5.,  5.,  5.]])
```

larray.arctan2

larray.**arctan2**(*x1*, *x2*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Element-wise arc tangent of `x1/x2` choosing the quadrant correctly.

larray specific variant of `numpy.arctan2`.

Documentation from numpy:

The quadrant (i.e., branch) is chosen so that `arctan2(x1, x2)` is the signed angle in radians between the ray ending at the origin and passing through the point (1,0), and the ray ending at the origin and passing through the point (*x2*, *x1*). (Note the role reversal: the "*y*-coordinate" is the first function parameter, the "*x*-coordinate" is the second.) By IEEE convention, this function is defined for *x2* = +/-0 and for either or both of *x1* and *x2* = +/-inf (see Notes for specific values).

This function is not defined for complex-valued arguments; for the so-called argument of complex values, use *angle*.

Parameters

x1 [array_like, real-valued] *y*-coordinates.

x2 [array_like, real-valued] *x*-coordinates. If `x1.shape != x2.shape`, they must be broadcastable to a common shape (which becomes the shape of the output).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

angle [ndarray] Array of angles in radians, in the range `[-pi, pi]`. This is a scalar if both *x1* and *x2* are scalars.

See also:

`arctan`, **`tan`**, **`angle`**

Notes

arctan2 is identical to the *atan2* function of the underlying C library. The following special values are defined in the C standard: [1]

x1	*x2*	*arctan2(x1,x2)*
+/- 0	+0	+/- 0
+/- 0	-0	+/- pi
> 0	+/-inf	+0 / +pi
< 0	+/-inf	-0 / -pi
+/-inf	+inf	+/- (pi/4)
+/-inf	-inf	+/- (3*pi/4)

Note that +0 and -0 are distinct floating point numbers, as are +inf and -inf.

References

[1]

Examples

Consider four points in different quadrants:

```
>>> x = np.array([-1, +1, +1, -1])
>>> y = np.array([-1, -1, +1, +1])
>>> np.arctan2(y, x) * 180 / np.pi
array([-135.,  -45.,   45.,  135.])
```

Note the order of the parameters. *arctan2* is defined also when *x2* = 0 and at several other special points, obtaining values in the range `[-pi, pi]`:

```
>>> np.arctan2([1., -1.], [0., 0.])
array([ 1.57079633, -1.57079633])
>>> np.arctan2([0., 0., np.inf], [+0., -0., np.inf])
array([ 0.        ,  3.14159265,  0.78539816])
```

larray.degrees

`larray.`**`degrees`**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Convert angles from radians to degrees.

larray specific variant of `numpy.degrees`.

Documentation from numpy:

Parameters

x [array_like] Input array in radians.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray of floats] The corresponding degree values; if *out* was supplied this is a reference to it. This is a scalar if *x* is a scalar.

See also:

`rad2deg` equivalent function

Examples

Convert a radian array to degrees

```
>>> rad = np.arange(12.)*np.pi/6
>>> np.degrees(rad)
array([   0.,   30.,   60.,   90.,  120.,  150.,  180.,  210.,  240.,
        270.,  300.,  330.])
```

```
>>> out = np.zeros((rad.shape))
>>> r = np.degrees(rad, out)
>>> np.all(r == out)
True
```

larray.radians

`larray.radians(x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True[, signature, extobj])`

Convert angles from degrees to radians.

larray specific variant of `numpy.radians`.

Documentation from numpy:

Parameters

x [array_like] Input array in degrees.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The corresponding radian values. This is a scalar if *x* is a scalar.

See also:

deg2rad equivalent function

Examples

Convert a degree array to radians

```
>>> deg = np.arange(12.) * 30.
>>> np.radians(deg)
array([ 0.        ,  0.52359878,  1.04719755,  1.57079633,  2.0943951 ,
        2.61799388,  3.14159265,  3.66519143,  4.1887902 ,  4.71238898,
        5.23598776,  5.75958653])
```

```
>>> out = np.zeros((deg.shape))
>>> ret = np.radians(deg, out)
>>> ret is out
True
```

larray.unwrap

larray.**unwrap**(**args*, ***kwargs*)

Unwrap by changing deltas between values to 2*pi complement.

larray specific variant of `numpy.unwrap`.

Documentation from numpy:

Unwrap radian phase *p* by changing absolute jumps greater than *discont* to their 2*pi complement along the given axis.

Parameters

p [array_like] Input array.

discont [float, optional] Maximum discontinuity between values, default is `pi`.

axis [int, optional] Axis along which unwrap will operate, default is the last axis.

Returns

out [ndarray] Output array.

See also:

rad2deg, deg2rad

Notes

If the discontinuity in *p* is smaller than `pi`, but larger than *discont*, no unwrapping is done because taking the 2*pi complement would only make the discontinuity larger.

Examples

```
>>> phase = np.linspace(0, np.pi, num=5)
>>> phase[3:] += np.pi
>>> phase
array([ 0.        ,  0.78539816,  1.57079633,  5.49778714,  6.28318531]) # may␣
↪vary
>>> np.unwrap(phase)
array([ 0.        ,  0.78539816,  1.57079633, -0.78539816,  0.        ]) # may␣
↪vary
```

Hyperbolic functions

sinh(x, /[, out, where, casting, order, ...])	Hyperbolic sine, element-wise.
cosh(x, /[, out, where, casting, order, ...])	Hyperbolic cosine, element-wise.

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tanh(x, /[, out, where, casting, order, …])	Compute hyperbolic tangent element-wise.
arcsinh(x, /[, out, where, casting, order, …])	Inverse hyperbolic sine element-wise.
arccosh(x, /[, out, where, casting, order, …])	Inverse hyperbolic cosine, element-wise.
arctanh(x, /[, out, where, casting, order, …])	Inverse hyperbolic tangent element-wise.

larray.sinh

larray.**sinh**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Hyperbolic sine, element-wise.

larray specific variant of `numpy.sinh`.

Documentation from numpy:

Equivalent to `1/2 * (np.exp(x) - np.exp(-x))` or `-1j * np.sin(1j*x)`.

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The corresponding hyperbolic sine values. This is a scalar if *x* is a scalar.

Notes

If *out* is provided, the function writes the result into it, and returns a reference to *out*. (See Examples)

References

M. Abramowitz and I. A. Stegun, Handbook of Mathematical Functions. New York, NY: Dover, 1972, pg. 83.

Examples

```
>>> np.sinh(0)
0.0
>>> np.sinh(np.pi*1j/2)
1j
>>> np.sinh(np.pi*1j) # (exact value is 0)
1.2246063538223773e-016j
>>> # Discrepancy due to vagaries of floating point arithmetic.
```

```
>>> # Example of providing the optional output parameter
>>> out1 = np.array([0], dtype='d')
>>> out2 = np.sinh([0.1], out1)
>>> out2 is out1
True
```

```
>>> # Example of ValueError due to provision of shape mis-matched `out`
>>> np.sinh(np.zeros((3,3)),np.zeros((2,2)))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operands could not be broadcast together with shapes (3,3) (2,2)
```

larray.cosh

larray.**cosh**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Hyperbolic cosine, element-wise.

larray specific variant of `numpy.cosh`.

Documentation from numpy:

Equivalent to `1/2 * (np.exp(x) + np.exp(-x))` and `np.cos(1j*x)`.

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Output array of same shape as *x*. This is a scalar if *x* is a scalar.

Examples

```
>>> np.cosh(0)
1.0
```

The hyperbolic cosine describes the shape of a hanging cable:

```
>>> import matplotlib.pyplot as plt
>>> x = np.linspace(-4, 4, 1000)
>>> plt.plot(x, np.cosh(x))
>>> plt.show()
```

larray.tanh

larray.**tanh**(*x*, */*, *out=None*, *, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Compute hyperbolic tangent element-wise.

larray specific variant of `numpy.tanh`.

Documentation from numpy:

Equivalent to `np.sinh(x)/np.cosh(x)` or `-1j * np.tan(1j*x)`.

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The corresponding hyperbolic tangent values. This is a scalar if *x* is a scalar.

Notes

If *out* is provided, the function writes the result into it, and returns a reference to *out*. (See Examples)

References

[1], [2]

Examples

```
>>> np.tanh((0, np.pi*1j, np.pi*1j/2))
array([ 0. +0.00000000e+00j,  0. -1.22460635e-16j,  0. +1.63317787e+16j])
```

```
>>> # Example of providing the optional output parameter illustrating
>>> # that what is returned is a reference to said parameter
>>> out1 = np.array([0], dtype='d')
>>> out2 = np.tanh([0.1], out1)
>>> out2 is out1
True
```

```
>>> # Example of ValueError due to provision of shape mis-matched `out`
>>> np.tanh(np.zeros((3,3)),np.zeros((2,2)))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operands could not be broadcast together with shapes (3,3) (2,2)
```

larray.arcsinh

`larray.arcsinh`(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Inverse hyperbolic sine element-wise.

larray specific variant of `numpy.arcsinh`.

Documentation from numpy:

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Array of the same shape as *x*. This is a scalar if *x* is a scalar.

Notes

arcsinh is a multivalued function: for each *x* there are infinitely many numbers *z* such that *sinh(z) = x*. The convention is to return the *z* whose imaginary part lies in *[-pi/2, pi/2]*.

For real-valued input data types, *arcsinh* always returns real output. For each value that cannot be expressed as a real number or infinity, it returns `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *arccos* is a complex analytical function that has branch cuts *[1j, infj]* and *[-1j, -infj]* and is continuous from the right on the former and from the left on the latter.

The inverse hyperbolic sine is also known as *asinh* or `sinh^-1`.

References

[1], [2]

Examples

```
>>> np.arcsinh(np.array([np.e, 10.0]))
array([ 1.72538256,  2.99822295])
```

larray.arccosh

larray.**arccosh**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Inverse hyperbolic cosine, element-wise.

larray specific variant of `numpy.arccosh`.

Documentation from numpy:

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

arccosh [ndarray] Array of the same shape as *x*. This is a scalar if *x* is a scalar.

See also:

`cosh`, `arcsinh`, `sinh`, `arctanh`, `tanh`

Notes

arccosh is a multivalued function: for each *x* there are infinitely many numbers *z* such that *cosh(z) = x*. The convention is to return the *z* whose imaginary part lies in *[-pi, pi]* and the real part in `[0, inf]`.

For real-valued input data types, *arccosh* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *arccosh* is a complex analytical function that has a branch cut *[-inf, 1]* and is continuous from above on it.

References

[1], [2]

Examples

```
>>> np.arccosh([np.e, 10.0])
array([ 1.65745445,  2.99322285])
>>> np.arccosh(1)
0.0
```

larray.arctanh

larray.**arctanh**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Inverse hyperbolic tangent element-wise.

larray specific variant of `numpy.arctanh`.

Documentation from numpy:

Parameters

x [array_like] Input array.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] Array of the same shape as *x*. This is a scalar if *x* is a scalar.

See also:

`emath.arctanh`

Notes

arctanh is a multivalued function: for each *x* there are infinitely many numbers *z* such that *tanh(z) = x*. The convention is to return the *z* whose imaginary part lies in *[-pi/2, pi/2]*.

For real-valued input data types, *arctanh* always returns real output. For each value that cannot be expressed as a real number or infinity, it yields `nan` and sets the *invalid* floating point error flag.

For complex-valued input, *arctanh* is a complex analytical function that has branch cuts *[-1, -inf]* and *[1, inf]* and is continuous from above on the former and from below on the latter.

The inverse hyperbolic tangent is also known as *atanh* or `tanh^-1`.

References

[1], [2]

Examples

```
>>> np.arctanh([0, -0.5])
array([ 0.        , -0.54930614])
```

Complex Numbers

angle(*args, **kwargs)	Return the angle of the complex argument.
real(*args, **kwargs)	Return the real part of the complex argument.
imag(*args, **kwargs)	Return the imaginary part of the complex argument.
conj(x, /[, out, where, casting, order, …])	Return the complex conjugate, element-wise.

larray.angle

larray.**angle**(**args*, ***kwargs*)

Return the angle of the complex argument.

larray specific variant of `numpy.angle`.

Documentation from numpy:

Parameters

z [array_like] A complex number or sequence of complex numbers.

deg [bool, optional] Return angle in degrees if True, radians if False (default).

Returns

angle [ndarray or scalar] The counterclockwise angle from the positive real axis on the complex plane in the range `(-pi, pi]`, with dtype as numpy.float64.

..versionchanged:: 1.16.0 This function works on subclasses of ndarray like *ma.array*.

See also:

arctan2

absolute

Examples

```
>>> np.angle([1.0, 1.0j, 1+1j])               # in radians
array([ 0.        ,  1.57079633,  0.78539816]) # may vary
>>> np.angle(1+1j, deg=True)                  # in degrees
45.0
```

larray.real

larray.**real**(**args*, ***kwargs*)

Return the real part of the complex argument.

larray specific variant of `numpy.real`.

Documentation from numpy:

Parameters

val [array_like] Input array.

Returns

out [ndarray or scalar] The real component of the complex argument. If *val* is real, the type of *val* is used for the output. If *val* has complex elements, the returned type is float.

See also:

real_if_close, ***imag***, ***angle***

Examples

```
>>> a = np.array([1+2j, 3+4j, 5+6j])
>>> a.real
array([1.,  3.,  5.])
>>> a.real = 9
>>> a
array([9.+2.j,  9.+4.j,  9.+6.j])
>>> a.real = np.array([9, 8, 7])
>>> a
array([9.+2.j,  8.+4.j,  7.+6.j])
>>> np.real(1 + 1j)
1.0
```

larray.imag

larray.**imag**(**args*, ***kwargs*)

Return the imaginary part of the complex argument.

larray specific variant of `numpy.imag`.

Documentation from numpy:

Parameters

val [array_like] Input array.

Returns

out [ndarray or scalar] The imaginary component of the complex argument. If *val* is real, the type of *val* is used for the output. If *val* has complex elements, the returned type is float.

See also:

real, ***angle***, **real_if_close**

Examples

```
>>> a = np.array([1+2j, 3+4j, 5+6j])
>>> a.imag
array([2.,  4.,  6.])
>>> a.imag = np.array([8, 10, 12])
>>> a
array([1. +8.j,  3.+10.j,  5.+12.j])
```

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```
>>> np.imag(1 + 1j)
1.0
```

larray.conj

larray.**conj**(*x, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True*[, *signature, extobj*])

Return the complex conjugate, element-wise.

larray specific variant of `numpy.conjugate`.

Documentation from numpy:

The complex conjugate of a complex number is obtained by changing the sign of its imaginary part.

Parameters

x [array_like] Input value.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray] The complex conjugate of *x*, with same dtype as *y*. This is a scalar if *x* is a scalar.

Notes

conj is an alias for *conjugate*:

```
>>> np.conj is np.conjugate
True
```

Examples

```
>>> np.conjugate(1+2j)
(1-2j)
```

```
>>> x = np.eye(2) + 1j * np.eye(2)
>>> np.conjugate(x)
array([[ 1.-1.j,  0.-0.j],
       [ 0.-0.j,  1.-1.j]])
```

Floating Point Routines

signbit(x, /[, out, where, casting, order, . . .])	Returns element-wise True where signbit is set (less than zero).
copysign(x1, x2, /[, out, where, casting, . . .])	Change the sign of x1 to that of x2, element-wise.
frexp(x[, out1, out2], / [[, out, where, . . .])	Decompose the elements of x into mantissa and twos exponent.
ldexp(x1, x2, /[, out, where, casting, . . .])	Returns x1 * 2**x2, element-wise.

larray.signbit

larray.**signbit**(*x*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Returns element-wise True where signbit is set (less than zero).

larray specific variant of `numpy.signbit`.

Documentation from numpy:

Parameters

x [array_like] The input value(s).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

result [ndarray of bool] Output array, or reference to *out* if that was supplied. This is a scalar if *x* is a scalar.

Examples

```
>>> np.signbit(-1.2)
True
>>> np.signbit(np.array([1, -2.3, 2.1]))
array([False,  True, False])
```

larray.copysign

larray.**copysign**(*x1*, *x2*, */*, *out=None*, ***, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Change the sign of x1 to that of x2, element-wise.

larray specific variant of `numpy.copysign`.

Documentation from numpy:

If *x2* is a scalar, its sign will be copied to all elements of *x1*.

Parameters

x1 [array_like] Values to change the sign of.

x2 [array_like] The sign of *x2* is copied to *x1*. If `x1.shape != x2.shape`, they must be broadcastable to a common shape (which becomes the shape of the output).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

out [ndarray or scalar] The values of *x1* with the sign of *x2*. This is a scalar if both *x1* and *x2* are scalars.

Examples

```
>>> np.copysign(1.3, -1)
-1.3
>>> 1/np.copysign(0, 1)
inf
>>> 1/np.copysign(0, -1)
-inf
```

```
>>> np.copysign([-1, 0, 1], -1.1)
array([-1., -0., -1.])
>>> np.copysign([-1, 0, 1], np.arange(3)-1)
array([-1.,  0.,  1.])
```

larray.frexp

`larray.`**`frexp`**(*x*[, *out1*, *out2*], / [, *out=(None, None)*], *, *where=True*, *casting='same_kind'*, *order='K'*, *dtype=None*, *subok=True*[, *signature*, *extobj*])

Decompose the elements of x into mantissa and twos exponent.

larray specific variant of `numpy.frexp`.

Documentation from numpy:

Returns (*mantissa*, *exponent*), where *x = mantissa * 2**exponent‘*. The mantissa is lies in the open interval(-1, 1), while the twos exponent is a signed integer.

Parameters

x [array_like] Array of numbers to be decomposed.

out1 [ndarray, optional] Output array for the mantissa. Must have the same shape as *x*.

out2 [ndarray, optional] Output array for the exponent. Must have the same shape as *x*.

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

mantissa [ndarray] Floating values between -1 and 1. This is a scalar if *x* is a scalar.

exponent [ndarray] Integer exponents of 2. This is a scalar if *x* is a scalar.

See also:

`ldexp` Compute `y = x1 * 2**x2`, the inverse of *frexp*.

Notes

Complex dtypes are not supported, they will raise a TypeError.

Examples

```
>>> x = np.arange(9)
>>> y1, y2 = np.frexp(x)
>>> y1
array([ 0.   ,  0.5  ,  0.5  ,  0.75 ,  0.5  ,  0.625,  0.75 ,  0.875,
        0.5  ])
>>> y2
array([0, 1, 2, 2, 3, 3, 3, 3, 4])
>>> y1 * 2**y2
array([ 0.,  1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.])
```

larray.ldexp

`larray.`**`ldexp`**(*x1, x2, /, out=None, *, where=True, casting='same_kind', order='K', dtype=None, subok=True*[, *signature, extobj*])

Returns x1 * 2**x2, element-wise.

larray specific variant of `numpy.ldexp`.

Documentation from numpy:

The mantissas *x1* and twos exponents *x2* are used to construct floating point numbers `x1 * 2**x2`.

Parameters

x1 [array_like] Array of multipliers.

x2 [array_like, int] Array of twos exponents. If `x1.shape != x2.shape`, they must be broadcastable to a common shape (which becomes the shape of the output).

out [ndarray, None, or tuple of ndarray and None, optional] A location into which the result is stored. If provided, it must have a shape that the inputs broadcast to. If not provided or *None*, a freshly-allocated array is returned. A tuple (possible only as a keyword argument) must have length equal to the number of outputs.

where [array_like, optional] This condition is broadcast over the input. At locations where the condition is True, the *out* array will be set to the ufunc result. Elsewhere, the *out* array will retain its original value. Note that if an uninitialized *out* array is created via the default `out=None`, locations within it where the condition is False will remain uninitialized.

****kwargs** For other keyword-only arguments, see the ufunc docs.

Returns

y [ndarray or scalar] The result of `x1 * 2**x2`. This is a scalar if both *x1* and *x2* are scalars.

See also:

frexp Return (y1, y2) from `x = y1 * 2**y2`, inverse to *ldexp*.

Notes

Complex dtypes are not supported, they will raise a TypeError.

ldexp is useful as the inverse of *frexp*, if used by itself it is more clear to simply use the expression `x1 * 2**x2`.

Examples

```
>>> np.ldexp(5, np.arange(4))
array([  5.,  10.,  20.,  40.], dtype=float16)
```

```
>>> x = np.arange(6)
>>> np.ldexp(*np.frexp(x))
array([ 0.,  1.,  2.,  3.,  4.,  5.])
```

4.3.7 Metadata

Metadata	An ordered dictionary allowing key-values accessibly using attribute notation (AttributeDict.attribute) instead of key notation (Dict["key"]).

larray.Metadata

class larray.**Metadata**

An ordered dictionary allowing key-values accessibly using attribute notation (AttributeDict.attribute) instead of key notation (Dict["key"]).

Examples

```
>>> from larray import ndtest
>>> from datetime import datetime
```

Add metadata at array initialization

```
>>> # Python 2 or <= 3.5
>>> arr = ndtest((3, 3), meta=[('title', 'the title'), ('author', 'John Smith')])
>>> # Python 3.6+
>>> arr = ndtest((3, 3), meta=Metadata(title='the title', author='John Smith'))
↪# doctest: +SKIP
```

Add metadata after array initialization

```
>>> arr.meta.creation_date = datetime(2017, 2, 10)
```

Access to metadata

```
>>> arr.meta.creation_date
datetime.datetime(2017, 2, 10, 0, 0)
```

Modify metadata

```
>>> arr.meta.creation_date = datetime(2017, 2, 16)
```

Delete metadata

```
>>> del arr.meta.creation_date
```

__init__(*self*, */*, **args*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

Methods

`__init__`(self, /, *args, **kwargs)	Initialize self.
`clear`()	
`copy`()	
`from_array`(array)	
`from_hdf`(hdfstore[, key])	
`fromkeys`()	If not specified, the value defaults to None.
`get`()	
`items`()	
`keys`()	
`move_to_end`()	Move an existing element to the end (or beginning if last==False).
`pop`()	value.
`popitem`(self, /[, last])	Remove and return a (key, value) pair from the dictionary.
`setdefault`()	
`to_hdf`(self, hdfstore[, key])	

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`update()`	If E is present and has a .keys() method, then does: for k in E: D[k] = E[k] If E is present and lacks a .keys() method, then does: for k, v in E: D[k] = v In either case, this is followed by: for k in F: D[k] = F[k]
`values()`	

4.3.8 Input/Output

Read

`read_csv`(filepath_or_buffer[, nb_axes, ...])	Reads csv file and returns an array with the contents.
`read_tsv`(filepath_or_buffer, **kwargs)	
`read_excel`(filepath[, sheet, nb_axes, ...])	Reads excel file from sheet name and returns an LArray with the contents
`read_hdf`(filepath_or_buffer, key[, ...])	Reads an axis or group or array named key from a HDF5 file in filepath (path+name)
`read_eurostat`(filepath_or_buffer, **kwargs)	Reads EUROSTAT TSV (tab-separated) file into an array.
`read_sas`(filepath[, nb_axes, index_col, ...])	Reads sas file and returns an LArray with the contents
`read_stata`(filepath_or_buffer[, index_col, ...])	Reads Stata .dta file and returns an LArray with the contents

larray.read_csv

`larray.`**`read_csv`**(*filepath_or_buffer*, *nb_axes=None*, *index_col=None*, *sep=', '*, *headersep=None*, *fill_value=nan*, *na=nan*, *sort_rows=False*, *sort_columns=False*, *wide=True*, *dialect='larray'*, ***kwargs*)

Reads csv file and returns an array with the contents.

Parameters

filepath_or_buffer [str or any file-like object] Path where the csv file has to be read or a file handle.

nb_axes [int or None, optional] Number of axes of output array. The first `nb_axes` - 1 columns and the header of the CSV file will be used to set the axes of the output array. If not specified, the number of axes is given by the position of the first column header including a \ character plus one. If no column header includes a \ character, the array is assumed to have one axis. Defaults to None.

index_col [list or None, optional] Positions of columns for the n-1 first axes (ex. [0, 1, 2, 3]). Defaults to None (see nb_axes above).

sep [str, optional] Separator.

headersep [str or None, optional] Separator for headers.

fill_value [scalar or LArray, optional] Value used to fill cells corresponding to label combinations which are not present in the input. Defaults to NaN.

sort_rows [bool, optional] Whether or not to sort the rows alphabetically (sorting is more efficient than not sorting). Defaults to False.

sort_columns [bool, optional] Whether or not to sort the columns alphabetically (sorting is more efficient than not sorting). Defaults to False.

wide [bool, optional] Whether or not to assume the array is stored in "wide" format. If False, the array is assumed to be stored in "narrow" format: one column per axis plus one value column. Defaults to True.

dialect [{'classic', 'larray', 'liam2'}, optional] Name of dialect. Defaults to 'larray'.

****kwargs** Extra keyword arguments are passed on to pandas.read_csv

Returns

LArray

Notes

Without using any argument to tell otherwise, the csv files are assumed to be in this format:

```
axis0_name,axis1_name\axis2_name,axis2_label0,axis2_label1
axis0_label0,axis1_label0,value,value
axis0_label0,axis1_label1,value,value
axis0_label1,axis1_label0,value,value
axis0_label1,axis1_label1,value,value
```

For example:

```
country,gender\time,2013,2014,2015
Belgium,Male,5472856,5493792,5524068
Belgium,Female,5665118,5687048,5713206
France,Male,31772665,31936596,32175328
France,Female,33827685,34005671,34280951
Germany,Male,39380976,39556923,39835457
Germany,Female,41142770,41210540,41362080
```

Examples

```
>>> csv_dir = get_example_filepath('examples')
>>> fname = csv_dir + '/pop.csv'
```

```
>>> # The data below is derived from a subset of the demo_pjan table from Eurostat
>>> read_csv(fname)
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male  31772665  31936596  32175328
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female  41142770  41210540  41362080
```

Missing label combinations

```
>>> fname = csv_dir + '/pop_missing_values.csv'
>>> # let's take a look inside the CSV file.
>>> # they are missing label combinations: (Paris, male) and (New York, female)
>>> with open(fname) as f:
```

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```
...     print(f.read().strip())
country,gender\time,2013,2014,2015
Belgium,Male,5472856,5493792,5524068
Belgium,Female,5665118,5687048,5713206
France,Female,33827685,34005671,34280951
Germany,Male,39380976,39556923,39835457
>>> # by default, cells associated with missing label combinations are filled␣
↪with NaN.
>>> # In that case, an int array is converted to a float array.
>>> read_csv(fname)
country  gender\time        2013        2014        2015
Belgium         Male   5472856.0   5493792.0   5524068.0
Belgium       Female   5665118.0   5687048.0   5713206.0
 France         Male         nan         nan         nan
 France       Female  33827685.0  34005671.0  34280951.0
Germany         Male  39380976.0  39556923.0  39835457.0
Germany       Female         nan         nan         nan
>>> # using argument 'fill_value', you can choose which value to use to fill␣
↪missing cells.
>>> read_csv(fname, fill_value=0)
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male         0         0         0
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female         0         0         0
```

Specify the number of axes of the output array (useful when the name of the last axis is implicit)

```
>>> fname = csv_dir + '/pop_missing_axis_name.csv'
>>> # let's take a look inside the CSV file.
>>> # The name of the last axis is missing.
>>> with open(fname) as f:
...     print(f.read().strip())
country,gender,2013,2014,2015
Belgium,Male,5472856,5493792,5524068
Belgium,Female,5665118,5687048,5713206
France,Male,31772665,31936596,32175328
France,Female,33827685,34005671,34280951
Germany,Male,39380976,39556923,39835457
Germany,Female,41142770,41210540,41362080
>>> # read the array stored in the CSV file as is
>>> arr = read_csv(fname)
>>> # we expected a 3 x 2 x 3 array with data of type int
>>> # but we got a 6 x 4 array with data of type object
>>> arr.info
6 x 4
 country [6]: 'Belgium' 'Belgium' 'France' 'France' 'Germany' 'Germany'
 {1} [4]: 'gender' '2013' '2014' '2015'
dtype: object
memory used: 192 bytes
>>> # using argument 'nb_axes', you can force the number of axes of the output␣
↪array
>>> arr = read_csv(fname, nb_axes=3)
>>> # as expected, we have a 3 x 2 x 3 array with data of type int
>>> arr.info
```

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```
3 x 2 x 3
 country [3]: 'Belgium' 'France' 'Germany'
 gender [2]: 'Male' 'Female'
 {2} [3]: 2013 2014 2015
dtype: int64
memory used: 144 bytes
```

Read array saved in "narrow" format (wide=False)

```
>>> fname = csv_dir + '/pop_narrow_format.csv'
>>> # let's take a look inside the CSV file.
>>> # Here, data are stored in a 'narrow' format.
>>> with open(fname) as f:
...     print(f.read().strip())
country,time,value
Belgium,2013,11137974
Belgium,2014,11180840
Belgium,2015,11237274
France,2013,65600350
France,2014,65942267
France,2015,66456279
>>> # to read arrays stored in 'narrow' format, you must pass wide=False to read_
↪csv
>>> read_csv(fname, wide=False)
country\time      2013      2014      2015
     Belgium  11137974  11180840  11237274
      France  65600350  65942267  66456279
```

larray.read_tsv

larray.**read_tsv**(*filepath_or_buffer*, ***kwargs*)

larray.read_excel

larray.**read_excel**(*filepath*, *sheet=0*, *nb_axes=None*, *index_col=None*, *fill_value=nan*, *na=nan*, *sort_rows=False*, *sort_columns=False*, *wide=True*, *engine=None*, *range=slice(None, None, None)*, ***kwargs*)

Reads excel file from sheet name and returns an LArray with the contents

Parameters

filepath [str] Path where the Excel file has to be read or use -1 to refer to the currently active workbook.

sheet [str, Group or int, optional] Name or index of the Excel sheet containing the array to be read. By default the array is read from the first sheet.

nb_axes [int, optional] Number of axes of output array. The first `nb_axes` - 1 columns and the header of the Excel sheet will be used to set the axes of the output array. If not specified, the number of axes is given by the position of the first column header including a \ character plus one. If no column header includes a \ character, the array is assumed to have one axis. Defaults to None.

index_col [list, optional] Positions of columns for the n-1 first axes (ex. [0, 1, 2, 3]). Defaults to None (see nb_axes above).

fill_value [scalar or LArray, optional] Value used to fill cells corresponding to label combinations which are not present in the input. Defaults to NaN.

sort_rows [bool, optional] Whether or not to sort the rows alphabetically (sorting is more efficient than not sorting). Defaults to False.

sort_columns [bool, optional] Whether or not to sort the columns alphabetically (sorting is more efficient than not sorting). Defaults to False.

wide [bool, optional] Whether or not to assume the array is stored in "wide" format. If False, the array is assumed to be stored in "narrow" format: one column per axis plus one value column. Defaults to True.

engine [{'xlrd', 'xlwings'}, optional] Engine to use to read the Excel file. If None (default), it will use 'xlwings' by default if the module is installed and relies on Pandas default reader otherwise.

range [str, optional] Range to load the array from (only supported for the 'xlwings' engine). Defaults to slice(None) which loads the whole sheet, ignoring blank cells in the bottom right corner.

****kwargs**

Returns

LArray

Examples

```
>>> fname = get_example_filepath('examples.xlsx')
```

Read array from first sheet

```
>>> # The data below is derived from a subset of the demo_pjan table from Eurostat
>>> read_excel(fname)
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male  31772665  31936596  32175328
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female  41142770  41210540  41362080
```

Read array from a specific sheet

```
>>> # The data below is derived from a subset of the demo_fasec table from␣
↪Eurostat
>>> read_excel(fname, 'births')
country  gender\time    2013    2014    2015
Belgium         Male   64371   64173   62561
Belgium       Female   61235   60841   59713
 France         Male  415762  418721  409145
 France       Female  396581  400607  390526
Germany         Male  349820  366835  378478
Germany       Female  332249  348092  359097
```

Missing label combinations

Let us take a look inside the sheet 'pop_missing_values'. Note the missing label combinations: (Paris, male) and (New York, female):

```
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
```

By default, cells associated with missing label combinations are filled with NaN. In that case, an int array is converted to a float array.

```
>>> read_excel(fname, sheet='pop_missing_values')
country  gender\time         2013         2014         2015
Belgium         Male    5472856.0    5493792.0    5524068.0
Belgium       Female    5665118.0    5687048.0    5713206.0
 France         Male          nan          nan          nan
 France       Female   33827685.0   34005671.0   34280951.0
Germany         Male   39380976.0   39556923.0   39835457.0
Germany       Female          nan          nan          nan
```

Using the `fill_value` argument, you can choose another value to use to fill missing cells.

```
>>> read_excel(fname, sheet='pop_missing_values', fill_value=0)
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male         0         0         0
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female         0         0         0
```

Specify the number of axes of the output array (useful when the name of the last axis is implicit)

The content of the sheet 'missing_axis_name' is:

```
country  gender      2013      2014      2015
Belgium    Male   5472856   5493792   5524068
Belgium  Female   5665118   5687048   5713206
 France    Male  31772665  31936596  32175328
 France  Female  33827685  34005671  34280951
Germany    Male  39380976  39556923  39835457
Germany  Female  41142770  41210540  41362080
```

```
>>> # read the array stored in the sheet 'pop_missing_axis_name' as is
>>> arr = read_excel(fname, sheet='pop_missing_axis_name')
>>> # we expected a 3 x 2 x 3 array with data of type int
>>> # but we got a 6 x 4 array with data of type object
>>> arr.info            # doctest: +SKIP
6 x 4
 country [6]: 'Belgium' 'Belgium' 'France' 'France' 'Germany' 'Germany'
 {1} [4]: 'gender' '2013' '2014' '2015'
dtype: object
memory used: 192 bytes
>>> # using argument 'nb_axes', you can force the number of axes of the output␣
↪array
>>> arr = read_excel(fname, sheet='pop_missing_axis_name', nb_axes=3)
>>> # as expected, we have a 3 x 2 x 3 array with data of type int
>>> arr.info            # doctest: +SKIP
3 x 2 x 3
```

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```
 country [3]: 'Belgium' 'France' 'Germany'
 gender [2]: 'Male' 'Female'
 {2} [3]: 2013 2014 2015
dtype: int64
memory used: 144 bytes
```

Read array saved in "narrow" format (wide=False)

Let us take a look inside the sheet 'pop_narrow' where the data is stored in a 'narrow' format:

```
country  time     value
Belgium  2013  11137974
Belgium  2014  11180840
Belgium  2015  11237274
 France  2013  65600350
 France  2014  65942267
 France  2015  66456279
```

```
>>> # to read arrays stored in 'narrow' format, you must pass wide=False to read_
↪excel
>>> read_excel(fname, 'pop_narrow_format', wide=False)
country\time      2013      2014      2015
     Belgium  11137974  11180840  11237274
      France  65600350  65942267  66456279
```

Extract array from a given range (xlwings only)

```
>>> read_excel(fname, 'pop_births_deaths', range='A9:E15')     # doctest: +SKIP
country  gender\time    2013    2014    2015
Belgium         Male   64371   64173   62561
Belgium       Female   61235   60841   59713
 France         Male  415762  418721  409145
 France       Female  396581  400607  390526
Germany         Male  349820  366835  378478
Germany       Female  332249  348092  359097
```

larray.read_hdf

`larray.read_hdf`(*filepath_or_buffer*, *key*, *fill_value=nan*, *na=nan*, *sort_rows=False*, *sort_columns=False*, *name=None*, ***kwargs*)

Reads an axis or group or array named key from a HDF5 file in filepath (path+name)

Parameters

filepath_or_buffer [str or pandas.HDFStore] Path and name where the HDF5 file is stored or a HDFStore object.

key [str or Group] Name of the array.

fill_value [scalar or LArray, optional] Value used to fill cells corresponding to label combinations which are not present in the input. Defaults to NaN.

sort_rows [bool, optional] Whether or not to sort the rows alphabetically. Must be False if the read array has been dumped with an larray version >= 0.30. Defaults to False.

sort_columns [bool, optional] Whether or not to sort the columns alphabetically. Must be False if the read array has been dumped with an larray version >= 0.30. Defaults to False.

name [str, optional] Name of the axis or group to return. If None, name is set to passed key. Defaults to None.

Returns

LArray

Examples

```
>>> fname = get_example_filepath('examples.h5')
```

Read array by passing its identifier (key) inside the HDF file

```
>>> # The data below is derived from a subset of the demo_pjan table from Eurostat
>>> read_hdf(fname, 'pop')
country  gender\time      2013      2014      2015
Belgium         Male   5472856   5493792   5524068
Belgium       Female   5665118   5687048   5713206
 France         Male  31772665  31936596  32175328
 France       Female  33827685  34005671  34280951
Germany         Male  39380976  39556923  39835457
Germany       Female  41142770  41210540  41362080
```

larray.read_eurostat

`larray.read_eurostat` (*filepath_or_buffer*, ***kwargs*)

Reads EUROSTAT TSV (tab-separated) file into an array.

EUROSTAT TSV files are special because they use tabs as data separators but comas to separate headers.

Parameters

filepath_or_buffer [str or any file-like object] Path where the tsv file has to be read or a file handle.

kwargs Arbitrary keyword arguments are passed through to read_csv.

Returns

LArray

larray.read_sas

`larray.read_sas` (*filepath*, *nb_axes=None*, *index_col=None*, *fill_value=nan*, *na=nan*, *sort_rows=False*, *sort_columns=False*, ***kwargs*)

Reads sas file and returns an LArray with the contents nb_axes: number of axes of the output array

or index_col: Positions of columns for the n-1 first axes (ex. [0, 1, 2, 3])

larray.read_stata

`larray.read_stata` (*filepath_or_buffer*, *index_col=None*, *sort_rows=False*, *sort_columns=False*, ***kwargs*)

Reads Stata .dta file and returns an LArray with the contents

Parameters

filepath_or_buffer [str or file-like object] Path to .dta file or a file handle.

index_col [str or None, optional] Name of column to set as index. Defaults to None.

sort_rows [bool, optional] Whether or not to sort the rows alphabetically (sorting is more efficient than not sorting). This only makes sense in combination with index_col. Defaults to False.

sort_columns [bool, optional] Whether or not to sort the columns alphabetically (sorting is more efficient than not sorting). Defaults to False.

Returns

LArray

See also:

LArray.to_stata

Notes

The round trip to Stata (LArray.to_stata followed by read_stata) loose the name of the "column" axis.

Examples

```
>>> read_stata('test.dta')                        # doctest: +SKIP
{0}\{1}  row  country  sex
      0    0       BE    F
      1    1       FR    M
      2    2       FR    F
>>> read_stata('test.dta', index_col='row')  # doctest: +SKIP
row\{1}  country  sex
      0       BE    F
      1       FR    M
      2       FR    F
```

Write

LArray.to_csv(self, filepath[, sep, na_rep, . . .])	Writes array to a csv file.
LArray.to_excel(self[, filepath, sheet, . . .])	Writes array in the specified sheet of specified excel workbook.
LArray.to_hdf(self, filepath, key)	Writes array to a HDF file.
LArray.to_stata(self, filepath_or_buffer, . . .)	Writes array to a Stata .dta file.
LArray.dump(self[, header, wide, . . .])	Dump array as a 2D nested list.

larray.LArray.to_csv

LArray.**to_csv**(*self, filepath, sep=', ', na_rep='', wide=True, value_name='value', dropna=None, dialect='default', **kwargs*)

Writes array to a csv file.

Parameters

filepath [str] path where the csv file has to be written.

sep [str, optional] separator for the csv file. Defaults to ,.

na_rep [str, optional] replace NA values with na_rep. Defaults to ‘’.

wide [boolean, optional] Whether or not writing arrays in “wide” format. If True, arrays are exported with the last axis represented horizontally. If False, arrays are exported in “narrow” format: one column per axis plus one value column. Defaults to True.

value_name [str, optional] Name of the column containing the values (last column) in the csv file when *wide=False* (see above). Defaults to ‘value’.

dialect [‘default’ | ‘classic’, optional] Whether or not to write the last axis name (using ‘’). Defaults to ‘default’.

dropna [None, ‘all’, ‘any’ or True, optional] Drop lines if ‘all’ its values are NA, if ‘any’ value is NA or do not drop any line (default). True is equivalent to ‘all’.

Examples

```
>>> tmpdir = getfixture('tmpdir')
>>> fname = os.path.join(tmpdir.strpath, 'test.csv')
>>> a = ndtest('nat=BE,FO;sex=M,F')
>>> a
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> a.to_csv(fname)
>>> with open(fname) as f:
...     print(f.read().strip())
nat\sex,M,F
BE,0,1
FO,2,3
>>> a.to_csv(fname, sep=';', wide=False)
>>> with open(fname) as f:
...     print(f.read().strip())
nat;sex;value
BE;M;0
BE;F;1
FO;M;2
FO;F;3
>>> a.to_csv(fname, sep=';', wide=False, value_name='population')
>>> with open(fname) as f:
...     print(f.read().strip())
nat;sex;population
BE;M;0
BE;F;1
FO;M;2
FO;F;3
>>> a.to_csv(fname, dialect='classic')
>>> with open(fname) as f:
...     print(f.read().strip())
nat,M,F
BE,0,1
FO,2,3
```

larray.LArray.to_excel

`LArray.to_excel`(*self*, *filepath=None*, *sheet=None*, *position='A1'*, *overwrite_file=False*, *clear_sheet=False*, *header=True*, *transpose=False*, *wide=True*, *value_name='value'*, *engine=None*, **args*, ***kwargs*)

Writes array in the specified sheet of specified excel workbook.

Parameters

filepath [str or int or None, optional] Path where the excel file has to be written. If None (default), creates a new Excel Workbook in a live Excel instance (Windows only). Use -1 to use the currently active Excel Workbook. Use a name without extension (.xlsx) to use any unsaved* workbook.

sheet [str or Group or int or None, optional] Sheet where the data has to be written. Defaults to None, Excel standard name if adding a sheet to an existing file, "Sheet1" otherwise. sheet can also refer to the position of the sheet (e.g. 0 for the first sheet, -1 for the last one).

position [str or tuple of integers, optional] Integer position (row, column) must be 1-based. Used only if engine is 'xlwings'. Defaults to 'A1'.

overwrite_file [bool, optional] Whether or not to overwrite the existing file (or just modify the specified sheet). Defaults to False.

clear_sheet [bool, optional] Whether or not to clear the existing sheet (if any) before writing. Defaults to False.

header [bool, optional] Whether or not to write a header (axes names and labels). Defaults to True.

transpose [bool, optional] Whether or not to transpose the array over last axis. This is equivalent to paste with option transpose in Excel. Defaults to False.

wide [boolean, optional] Whether or not writing arrays in "wide" format. If True, arrays are exported with the last axis represented horizontally. If False, arrays are exported in "narrow" format: one column per axis plus one value column. Defaults to True.

value_name [str, optional] Name of the column containing the values (last column) in the Excel sheet when *wide=False* (see above). Defaults to 'value'.

engine ['xlwings' | 'openpyxl' | 'xlsxwriter' | 'xlwt' | None, optional] Engine to use to make the output. If None (default), it will use 'xlwings' by default if the module is installed and relies on Pandas default writer otherwise.

***args**

****kwargs**

Examples

```
>>> a = ndtest('nat=BE,FO;sex=M,F')
>>> # write to a new (unnamed) sheet
>>> a.to_excel('test.xlsx')  # doctest: +SKIP
>>> # write to top-left corner of an existing sheet
>>> a.to_excel('test.xlsx', 'Sheet1')  # doctest: +SKIP
>>> # add to existing sheet starting at position A15
>>> a.to_excel('test.xlsx', 'Sheet1', 'A15')  # doctest: +SKIP
```

larray.LArray.to_hdf

`LArray.to_hdf(self, filepath, key)`

Writes array to a HDF file.

A HDF file can contain multiple arrays. The 'key' parameter is a unique identifier for the array.

Parameters

filepath [str] Path where the hdf file has to be written.

key [str or Group] Key (path) of the array within the HDF file (see Notes below).

Notes

Objects stored in a HDF file can be grouped together in *HDF groups*. If an object 'my_obj' is stored in a HDF group 'my_group', the key associated with this object is then 'my_group/my_obj'. Be aware that a HDF group can have subgroups.

Examples

```
>>> a = ndtest((2, 3))
```

Save an array

```
>>> a.to_hdf('test.h5', 'a')          # doctest: +SKIP
```

Save an array in a specific HDF group

```
>>> a.to_hdf('test.h5', 'arrays/a')  # doctest: +SKIP
```

larray.LArray.to_stata

`LArray.to_stata(self, filepath_or_buffer, **kwargs)`

Writes array to a Stata .dta file.

Parameters

filepath_or_buffer [str or file-like object] Path to .dta file or a file handle.

See also:

read_stata

Notes

The round trip to Stata (LArray.to_stata followed by read_stata) loose the name of the "column" axis.

Examples

```
>>> axes = [Axis(3, 'row'), Axis('column=country,sex')]     # doctest: +SKIP
>>> arr = LArray([['BE', 'F'],
...               ['FR', 'M'],
...               ['FR', 'F']], axes=axes)                   # doctest: +SKIP
>>> arr                                                      # doctest: +SKIP
row*\column  age  sex
          0    5    F
          1   25    M
          2   30    F
>>> arr.to_stata('test.dta')                                 # doctest: +SKIP
```

larray.LArray.dump

LArray.**dump**(*self*, *header=True*, *wide=True*, *value_name='value'*, *light=False*, *axes_names=True*, *na_repr='as_is'*, *maxlines=-1*, *edgeitems=5*)

Dump array as a 2D nested list. This is especially useful when writing to an Excel sheet via open_excel().

Parameters

header [bool] Whether or not to output axes names and labels.

wide [boolean, optional] Whether or not to write arrays in "wide" format. If True, arrays are exported with the last axis represented horizontally. If False, arrays are exported in "narrow" format: one column per axis plus one value column. Not used if header=False. Defaults to True.

value_name [str, optional] Name of the column containing the values (last column) when *wide=False* (see above). Not used if header=False. Defaults to 'value'.

light [bool, optional] Whether or not to hide repeated labels. In other words, only show a label if it is different from the previous one. Defaults to False.

axes_names [bool or 'except_last', optional] Assuming header is True, whether or not to include axes names. If axes_names is 'except_last', all axes names will be included except the last. Defaults to True.

na_repr [any scalar, optional] Replace missing values (NaN floats) by this value. Default to 'as_is' (do not do any replacement).

maxlines [int, optional] Maximum number of lines to show. Defaults to -1 (all lines are shown).

edgeitems [int, optional] If number of lines to display is greater than *maxlines*, only the first and last *edgeitems* lines are displayed. Only active if *maxlines* is not -1. Defaults to 5.

Returns

2D nested list or None for 0d arrays

Examples

```
>>> arr = ndtest((2, 2, 2))
>>> arr.dump()                               # doctest: +NORMALIZE_WHITESPACE
[['a',  'b\\c', 'c0', 'c1'],
 ['a0',   'b0',    0,    1],
 ['a0',   'b1',    2,    3],
 ['a1',   'b0',    4,    5],
```

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```
 ['a1',    'b1',    6,    7]]
>>> arr.dump(axes_names=False)              # doctest: +NORMALIZE_WHITESPACE
[['',        '', 'c0', 'c1'],
 ['a0',    'b0',    0,    1],
 ['a0',    'b1',    2,    3],
 ['a1',    'b0',    4,    5],
 ['a1',    'b1',    6,    7]]
>>> arr.dump(axes_names='except_last')      # doctest: +NORMALIZE_WHITESPACE
[['a',      'b', 'c0', 'c1'],
 ['a0',    'b0',    0,    1],
 ['a0',    'b1',    2,    3],
 ['a1',    'b0',    4,    5],
 ['a1',    'b1',    6,    7]]
>>> arr.dump(light=True)                    # doctest: +NORMALIZE_WHITESPACE
[['a',  'b\\c', 'c0', 'c1'],
 ['a0',    'b0',    0,    1],
 ['',      'b1',    2,    3],
 ['a1',    'b0',    4,    5],
 ['',      'b1',    6,    7]]
>>> arr.dump(wide=False, value_name='data')  # doctest: +NORMALIZE_WHITESPACE
[['a',   'b',   'c', 'data'],
 ['a0', 'b0', 'c0',      0],
 ['a0', 'b0', 'c1',      1],
 ['a0', 'b1', 'c0',      2],
 ['a0', 'b1', 'c1',      3],
 ['a1', 'b0', 'c0',      4],
 ['a1', 'b0', 'c1',      5],
 ['a1', 'b1', 'c0',      6],
 ['a1', 'b1', 'c1',      7]]
>>> arr.dump(maxlines=3, edgeitems=1)       # doctest: +NORMALIZE_WHITESPACE
[['a',   'b\\c',   'c0',   'c1'],
 ['a0',    'b0',      0,      1],
 ['...',  '...',  '...',  '...'],
 ['a1',    'b1',      6,      7]]
```

4.3.9 Excel

open_excel([filepath, overwrite_file, . . .])	Open an Excel workbook

larray.open_excel

larray.**open_excel**(*filepath=None*, *overwrite_file=False*, *visible=None*, *silent=None*, *app=None*, *load_addins=None*)

Open an Excel workbook

Parameters

filepath [None, int or str, optional] path to the Excel file. The file must exist if overwrite_file is False. Use None for a new blank workbook, -1 for the currently active workbook. Defaults to None.

overwrite_file [bool, optional] whether or not to overwrite an existing file, if any. Defaults to False.

visible [None or bool, optional] whether or not Excel should be visible. Defaults to False for files, True for new/active workbooks and to None ("unchanged") for existing unsaved workbooks.

silent [None or bool, optional] whether or not to show dialog boxes for updating links or when some links cannot be updated. Defaults to False if visible, True otherwise.

app [None, "new", "active", "global" or xlwings.App, optional] use "new" for opening a new Excel instance, "active" for the last active instance (including ones opened by the user) and "global" to (re)use the same instance for all workbooks of a program. None is equivalent to "active" if filepath is -1, "new" if visible is True and "global" otherwise. Defaults to None.

The "global" instance is a specific Excel instance for all input from/output to Excel from within a single Python program (and should not interact with instances manually opened by the user or another program).

load_addins [None or bool, optional] whether or not to load Excel addins. Defaults to True if visible and app == "new", False otherwise.

Returns

Excel workbook.

Examples

```
>>> arr = ndtest((3, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
 a2   6   7   8
```

create a new Excel file and save an array

```
>>> # to create a new Excel file, argument overwrite_file must be set to True
>>> with open_excel('excel_file.xlsx', overwrite_file=True) as wb:   # doctest:␣
↪+SKIP
...     wb['arr'] = arr.dump()
...     wb.save()
```

read array from an Excel file

```
>>> with open_excel('excel_file.xlsx') as wb:    # doctest: +SKIP
...     arr2 = wb['arr'].load()
>>> arr2    # doctest: +SKIP
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
 a2   6   7   8
```

Workbook([filepath, overwrite_file, . . .])	Excel Workbook.
Workbook.sheet_names(self)	Returns the names of the Excel sheets.
Workbook.save(self[, path])	Saves the Workbook.
Workbook.close(self)	Close the workbook in Excel.
Workbook.app(self)	Return the Excel instance this workbook is attached to.

larray.Workbook

class larray.**Workbook**(*filepath=None*, *overwrite_file=False*, *visible=None*, *silent=None*, *app=None*, *load_addins=None*)

Excel Workbook.

See also:

open_excel

__init__(*self*, *filepath=None*, *overwrite_file=False*, *visible=None*, *silent=None*, *app=None*, *load_addins=None*)

Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self[, filepath, overwrite_file, . . .])	Initialize self.
app(self)	Return the Excel instance this workbook is attached to.
close(self)	Close the workbook in Excel.
save(self[, path])	Saves the Workbook.
sheet_names(self)	Returns the names of the Excel sheets.

larray.Workbook.sheet_names

Workbook.**sheet_names**(*self*)

Returns the names of the Excel sheets.

Examples

```
>>> arr, arr2, arr3 = ndtest((3, 3)), ndtest((2, 2)), ndtest(4)
>>> with open_excel('excel_file.xlsx', overwrite_file=True) as wb:   # doctest:
↪+SKIP
...     wb['arr'] = arr.dump()
...     wb['arr2'] = arr2.dump()
...     wb['arr3'] = arr3.dump()
...     wb.save()
...
...     wb.sheet_names()
['arr', 'arr2', 'arr3']
```

larray.Workbook.save

Workbook.**save**(*self*, *path=None*)

Saves the Workbook.

If a path is being provided, this works like SaveAs() in Excel. If no path is specified and if the file hasn't been saved previously, it's being saved in the current working directory with the current filename. Existing files are overwritten without prompting.

Parameters

path [str, optional] Full path to the workbook. Defaults to None.

Examples

```
>>> arr, arr2, arr3 = ndtest((3, 3)), ndtest((2, 2)), ndtest(4)
>>> with open_excel('excel_file.xlsx', overwrite_file=True) as wb:    # doctest:␣
↪+SKIP
...     wb['arr'] = arr.dump()
...     wb['arr2'] = arr2.dump()
...     wb['arr3'] = arr3.dump()
...     wb.save()
```

larray.Workbook.close

`Workbook.close(self)`

Close the workbook in Excel.

Need to be called if the workbook has been opened without the *with* statement.

Examples

```
>>> arr, arr2, arr3 = ndtest((3, 3)), ndtest((2, 2)), ndtest(4)   # doctest: +SKIP
>>> wb = open_excel('excel_file.xlsx', overwrite_file=True)        # doctest: +SKIP
>>> wb['arr'] = arr.dump()                                         # doctest: +SKIP
>>> wb['arr2'] = arr2.dump()                                       # doctest: +SKIP
>>> wb['arr3'] = arr3.dump()                                       # doctest: +SKIP
>>> wb.save()                                                      # doctest: +SKIP
>>> wb.close()                                                     # doctest: +SKIP
```

larray.Workbook.app

`Workbook.app(self)`

Return the Excel instance this workbook is attached to.

4.3.10 ExcelReport

ExcelReport()	Automate the generation of multiple graphs in an Excel file.
ExcelReport.template_dir	Set the path to the directory containing the Excel template files (with '.crtx' extension).
ExcelReport.template	Set a default Excel template file.
ExcelReport.set_item_default_size(self, kind)	Override the default 'width' and 'height' values for the given kind of item.
ExcelReport.graphs_per_row	Default number of graphs per row.
ExcelReport.new_sheet(self, sheet_name)	Add a new empty output sheet.
ExcelReport.sheet_names(self)	Returns the names of the output sheets.
ExcelReport.to_excel(self, filepath[, …])	Generate the report Excel file.

larray.ExcelReport

class larray.**ExcelReport**

Automate the generation of multiple graphs in an Excel file.

The ExcelReport instance is initially populated with information (data, title, destination sheet, template, size) required to create the graphs. Once all information has been provided, the *to_excel* method is called to generate an Excel file with all graphs in one step.

Parameters

template_dir [str, optional] Path to the directory containing the Excel template files (with a '.crtx' extension). Defaults to None.

template [str, optional] Name of the template to be used as default template. The extension '.crtx' will be added if not given. The full path to the template file must be given if no template directory has been set. Defaults to None.

graphs_per_row: int, optional Default number of graphs per row. Defaults to 1.

Notes

The data associated with all graphical items is dumped in the same sheet named '__data__'.

Examples

```
>>> demo = load_example_data('demo')
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
```

Set a new destination sheet

```
>>> sheet_be = report.new_sheet('Belgium')
```

Add a new title item

```
>>> sheet_be.add_title('Population, births and deaths')
```

Add a new graph item (each new graph is placed right to previous one unless you use newline() or add_title())

```
>>> # using default 'width' and 'height' values
>>> sheet_be.add_graph(demo.pop['Belgium'], 'Population', template='Line')
>>> # specifying the 'width' and 'height' values
>>> sheet_be.add_graph(demo.births['Belgium'], 'Births', template='Line',␣
↪width=450, height=250)
```

Override the default 'width' and 'height' values for graphs

```
>>> sheet_be.set_item_default_size('graph', width=450, height=250)
>>> # add a new graph with the new default 'width' and 'height' values
>>> sheet_be.add_graph(demo.deaths['Belgium'], 'Deaths')
```

Set a default template for all next graphs

```
>>> # if a default template directory has been set, just pass the name
>>> sheet_be.template = 'Line'
>>> # otherwise, give the full path to the template file
>>> sheet_be.template = r'C:\other_template_dir\Line_Marker.crtx' # doctest: +SKIP
>>> # add a new graph with the default template
>>> sheet_be.add_graph(demo.pop['Belgium', 'Female'], 'Population - Female')
>>> sheet_be.add_graph(demo.pop['Belgium', 'Male'], 'Population - Male')
```

Specify the number of graphs per row

```
>>> sheet_countries = report.new_sheet('All countries')
```

```
>>> sheet_countries.graphs_per_row = 2
>>> for combined_labels, subset in demo.pop.items(('time', 'gender')):
...     title = ' - '.join([str(label) for label in combined_labels])
...     sheet_countries.add_graph(subset, title)
```

Force a new row of graphs

```
>>> sheet_countries.newline()
```

Add multiple graphs at once (add a new graph for each combination of gender and year)

```
>>> sheet_countries.add_graphs({'Population of {gender} by country for the year
↪{year}': pop},
...                            {'gender': pop.gender, 'year': pop.time},
...                            template='line', width=450, height=250, graphs_per_
↪row=2)
```

Generate the report Excel file

```
>>> report.to_excel('Demography_Report.xlsx')
```

__init__(*self*)
Initialize self. See help(type(self)) for accurate signature.

Methods

`__init__`(self)	Initialize self.
`new_sheet`(self, sheet_name)	Add a new empty output sheet.
`set_item_default_size`(self, kind[, width, ...])	Override the default 'width' and 'height' values for the given kind of item.
`sheet_names`(self)	Returns the names of the output sheets.
`to_excel`(self, filepath[, data_sheet_name, ...])	Generate the report Excel file.

Attributes

`graphs_per_row`	Default number of graphs per row.
`template`	Set a default Excel template file.
`template_dir`	Set the path to the directory containing the Excel template files (with '.crtx' extension).

larray.ExcelReport.template_dir

property ExcelReport.**template_dir**
Set the path to the directory containing the Excel template files (with '.crtx' extension). This method is mainly useful if your template files are located in several directories, otherwise pass the template directory directly the ExcelReport constructor.

Parameters

template_dir [str] Path to the directory containing the Excel template files.

See also:

set_graph_template

Examples

```
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
>>> # ... add some graphs using template files from 'C:\excel_templates_dir'
>>> report.template_dir = r'C:\other_templates_dir' # doctest: +SKIP
>>> # ... add some graphs using template files from 'C:\other_templates_dir'
```

larray.ExcelReport.template

property ExcelReport.**template**

Set a default Excel template file.

Parameters

template_file [str] Name of the template to be used as default template. The extension '.crtx' will be added if not given. The full path to the template file must be given if no template directory has been set.

Examples

```
>>> demo = load_example_data('demo')
```

Passing the name of the template (only if a template directory has been set)

```
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
>>> report.template = 'Line'
```

```
>>> sheet_pop = report.new_sheet('Population')
>>> sheet_pop.add_graph(demo.pop['Belgium'],'Belgium')
```

Passing the full path of the template file

```
>>> # if no default template directory has been set
>>> # or if the new template is located in another directory,
>>> # you must provide the full path
>>> sheet_pop.template = r'C:\other_templates_dir\Line_Marker.crtx' # doctest:␣
↪+SKIP
>>> sheet_pop.add_graph(demo.pop['Germany'],'Germany') # doctest: +SKIP
```

larray.ExcelReport.set_item_default_size

ExcelReport.**set_item_default_size**(*self*, *kind*, *width=None*, *height=None*)

Override the default 'width' and 'height' values for the given kind of item. A new value must be provided at least for 'width' or 'height'.

Parameters

kind [str] kind of item for which default values of 'width' and/or 'height' are modified. Currently available kinds are 'title' and 'graph'.

width [int, optional] new default width value.

height [int, optional] new default height value.

Examples

```
>>> report = ExcelReport()
>>> report.set_item_default_size('graph', width=450, height=250)
```

larray.ExcelReport.graphs_per_row

property `ExcelReport.`**`graphs_per_row`**

Default number of graphs per row.

Parameters

graphs_per_row: int

See also:

`ReportSheet.newline`

larray.ExcelReport.new_sheet

`ExcelReport.`**`new_sheet`**(*self*, *sheet_name*)

Add a new empty output sheet. This sheet will contain only graphical elements, all data are exported to a dedicated separate sheet.

Parameters

sheet_name [str] name of the current sheet.

Returns

sheet: SheetReport

Examples

```
>>> demo = load_example_data('demo')
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
```

```
>>> # prepare new output sheet named 'Belgium'
>>> sheet_be = report.new_sheet('Belgium')
```

```
>>> # add graph to the output sheet 'Belgium'
>>> sheet_be.add_graph(demo.pop['Belgium'], 'Population', template='Line')
```

larray.ExcelReport.sheet_names

`ExcelReport.`**`sheet_names`**(*self*)

Returns the names of the output sheets.

Examples

```
>>> report = ExcelReport()
>>> sheet_pop = report.new_sheet('Pop')
>>> sheet_births = report.new_sheet('Births')
>>> sheet_deaths = report.new_sheet('Deaths')
>>> report.sheet_names()
['Pop', 'Births', 'Deaths']
```

larray.ExcelReport.to_excel

ExcelReport.**to_excel**(*self*, *filepath*, *data_sheet_name='__data__'*, *overwrite=True*)

Generate the report Excel file.

Parameters

filepath [str] Path of the report file for the dump.

data_sheet_name [str, optional] name of the Excel sheet where all data associated with items is dumped. Defaults to '__data__'.

overwrite [bool, optional] whether or not to overwrite an existing report file. Defaults to True.

Examples

```
>>> demo = load_example_data('demo')
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
>>> report.template = 'Line_Marker'
```

```
>>> for c in demo.country:
...     sheet_country = report.new_sheet(c)
...     sheet_country.add_graph(demo.pop[c], 'Population')
...     sheet_country.add_graph(demo.births[c], 'Births')
...     sheet_country.add_graph(demo.deaths[c], 'Deaths')
```

Basic usage

```
>>> report.to_excel('Demography_Report.xlsx')
```

Alternative data sheet name

```
>>> report.to_excel('Demography_Report.xlsx', data_sheet_name='Data Tables') #␣
↪doctest: +SKIP
```

Check if ouput file already exists

```
>>> report.to_excel('Demography_Report.xlsx', overwrite=False) # doctest: +SKIP
Traceback (most recent call last):
...
ValueError: Sheet named 'Belgium' already present in workbook
```

4.3.11 ReportSheet

ReportSheet()	Represents a sheet dedicated to contains only graphical items (title banners, graphs).
ReportSheet.template_dir	Set the path to the directory containing the Excel template files (with '.crtx' extension).
ReportSheet.template	Set a default Excel template file.
ReportSheet.set_item_default_size(self, kind)	Override the default 'width' and 'height' values for the given kind of item.
ReportSheet.graphs_per_row	Default number of graphs per row.
ReportSheet.add_title(self, title[, width, ...])	Add a title item to the current sheet.
ReportSheet.add_graph(self, data[, title, ...])	Add a graph item to the current sheet.
ReportSheet.add_graphs(self, ...[, ...])	Add multiple graph items to the current sheet.
ReportSheet.newline(self)	Force a new row of graphs.

larray.ReportSheet

class larray.**ReportSheet**

Represents a sheet dedicated to contains only graphical items (title banners, graphs). See ExcelReport for use cases.

Parameters

template_dir [str, optional] Path to the directory containing the Excel template files (with a '.crtx' extension). Defaults to None.

template [str, optional] Name of the template to be used as default template. The extension '.crtx' will be added if not given. The full path to the template file must be given if no template directory has been set. Defaults to None.

graphs_per_row: int, optional Default number of graphs per row. Defaults to 1.

See also:

ExcelReport

__init__(*self*)

Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self)	Initialize self.
add_graph(self, data[, title, template, ...])	Add a graph item to the current sheet.
add_graphs(self, array_per_title, ...[, ...])	Add multiple graph items to the current sheet.
add_title(self, title[, width, height, fontsize])	Add a title item to the current sheet.
newline(self)	Force a new row of graphs.
set_item_default_size(self, kind[, width, ...])	Override the default 'width' and 'height' values for the given kind of item.

Attributes

graphs_per_row	Default number of graphs per row.
template	Set a default Excel template file.

Continued on next page

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template_dir	Set the path to the directory containing the Excel template files (with '.crtx' extension).

larray.ReportSheet.template_dir

property ReportSheet.**template_dir**

Set the path to the directory containing the Excel template files (with '.crtx' extension). This method is mainly useful if your template files are located in several directories, otherwise pass the template directory directly the ExcelReport constructor.

Parameters

template_dir [str] Path to the directory containing the Excel template files.

See also:

set_graph_template

Examples

```
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
>>> # ... add some graphs using template files from 'C:\excel_templates_dir'
>>> report.template_dir = r'C:\other_templates_dir' # doctest: +SKIP
>>> # ... add some graphs using template files from 'C:\other_templates_dir'
```

larray.ReportSheet.template

property ReportSheet.**template**

Set a default Excel template file.

Parameters

template_file [str] Name of the template to be used as default template. The extension '.crtx' will be added if not given. The full path to the template file must be given if no template directory has been set.

Examples

```
>>> demo = load_example_data('demo')
```

Passing the name of the template (only if a template directory has been set)

```
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
>>> report.template = 'Line'
```

```
>>> sheet_pop = report.new_sheet('Population')
>>> sheet_pop.add_graph(demo.pop['Belgium'],'Belgium')
```

Passing the full path of the template file

```
>>> # if no default template directory has been set
>>> # or if the new template is located in another directory,
>>> # you must provide the full path
>>> sheet_pop.template = r'C:\other_templates_dir\Line_Marker.crtx' # doctest:␣
↪+SKIP
>>> sheet_pop.add_graph(demo.pop['Germany'],'Germany') # doctest: +SKIP
```

larray.ReportSheet.set_item_default_size

`ReportSheet.set_item_default_size`(*self*, *kind*, *width=None*, *height=None*)

Override the default 'width' and 'height' values for the given kind of item. A new value must be provided at least for 'width' or 'height'.

Parameters

kind [str] kind of item for which default values of 'width' and/or 'height' are modified. Currently available kinds are 'title' and 'graph'.

width [int, optional] new default width value.

height [int, optional] new default height value.

Examples

```
>>> report = ExcelReport()
>>> report.set_item_default_size('graph', width=450, height=250)
```

larray.ReportSheet.graphs_per_row

property `ReportSheet.graphs_per_row`

Default number of graphs per row.

Parameters

graphs_per_row: int

See also:

ReportSheet.newline

larray.ReportSheet.add_title

`ReportSheet.add_title`(*self*, *title*, *width=None*, *height=None*, *fontsize=11*)

Add a title item to the current sheet. Note that the current method only add a new item to the list of items to be generated. The report Excel file is generated only when the *to_excel* is called.

Parameters

title [str] Text to write in the title item.

width [int, optional] width of the title item. The current default value is used if None (see *set_item_default_size*). Defaults to None.

height [int, optional] height of the title item. The current default value is used if None (see *set_item_default_size*). Defaults to None.

fontsize [int, optional] fontsize of the displayed text. Defaults to 11.

Examples

```
>>> report = ExcelReport()
```

```
>>> first_sheet = report.new_sheet('First_sheet')
>>> first_sheet.add_title('Title banner with default width, height and fontsize')
>>> first_sheet.add_title('Larger title banner', width=1200, height=100)
>>> first_sheet.add_title('Bigger fontsize', fontsize=13)
```

```
>>> # do not forget to call 'to_excel' to create the report file
>>> report.to_excel('Report.xlsx')
```

larray.ReportSheet.add_graph

ReportSheet.**add_graph**(*self, data, title=None, template=None, width=None, height=None*)

Add a graph item to the current sheet. Note that the current method only add a new item to the list of items to be generated. The report Excel file is generated only when the `to_excel` is called.

Parameters

data [1D or 2D array-like] 1D or 2D array representing the data associated with the graph. The first row represents the abscissa labels. Each additional row represents a new series and must start with the name of the current series.

title [str, optional] title of the graph. Defaults to None.

template [str, optional] name of the template to be used to generate the graph. The full path to the template file must be provided if no template directory has not been set or if the template file belongs to another directory. Defaults to the defined template (see `set_graph_template`).

width [int, optional] width of the title item. The current default value is used if None (see `set_item_default_size`). Defaults to None.

height [int, optional] height of the title item. The current default value is used if None (see `set_item_default_size`). Defaults to None.

Examples

```
>>> demo = load_example_data('demo')
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
```

```
>>> sheet_be = report.new_sheet('Belgium')
```

Specifying the 'template'

```
>>> sheet_be.add_graph(demo.pop['Belgium'], 'Population', template='Line')
```

Specifying the 'template', 'width' and 'height' values

```
>>> sheet_be.add_graph(demo.births['Belgium'], 'Births', template='Line',␣
↪width=450, height=250)
```

Setting a default template

```
>>> sheet_be.template = 'Line_Marker'
>>> sheet_be.add_graph(demo.deaths['Belgium'], 'Deaths')
```

Dumping the report Excel file

```
>>> # do not forget to call 'to_excel' to create the report file
>>> report.to_excel('Demography_Report.xlsx')
```

larray.ReportSheet.add_graphs

ReportSheet.**add_graphs**(*self*, *array_per_title*, *axis_per_loop_variable*, *template=None*, *width=None*, *height=None*, *graphs_per_row=1*)

Add multiple graph items to the current sheet. This method is mainly useful when multiple graphs are generated by iterating over one or several axes of an array (see examples below). The report Excel file is generated only when the `to_excel` is called.

Parameters

array_per_title: dict dictionary containing pairs (title template, array).

axis_per_loop_variable: dict dictionary containing pairs (variable used in the title template, axis).

template [str, optional] name of the template to be used to generate the graph. The full path to the template file must be provided if no template directory has not been set or if the template file belongs to another directory. Defaults to the defined template (see `set_graph_template`).

width [int, optional] width of the title item. The current default value is used if None (see `set_item_default_size`). Defaults to None.

height [int, optional] height of the title item. The current default value is used if None (see `set_item_default_size`). Defaults to None.

graphs_per_row: int, optional Number of graphs per row. Defaults to 1.

Examples

```
>>> demo = load_example_data('demo')
>>> report = ExcelReport(EXAMPLE_EXCEL_TEMPLATES_DIR)
```

```
>>> sheet_pop = report.new_sheet('Population')
>>> pop = demo.pop
```

Generate a new graph for each combination of gender and year

```
>>> sheet_pop.add_graphs({'Population of {gender} by country for the year {year}
↪': pop},
...                      {'gender': pop.gender, 'year': pop.time},
...                      template='line', width=450, height=250, graphs_per_row=2)
```

```
>>> # do not forget to call 'to_excel' to create the report file
>>> report.to_excel('Demography_Report.xlsx')
```

larray.ReportSheet.newline

ReportSheet.**newline**(*self*)
Force a new row of graphs.

4.3.12 Miscellaneous

aslarray(a[, meta])	Converts input as LArray if possible.
from_frame(df[, sort_rows, sort_columns, …])	Converts Pandas DataFrame into LArray.
from_series(s[, sort_rows, fill_value, meta])	Converts Pandas Series into LArray.
get_example_filepath(fname)	Return absolute path to an example file if exist.
set_options(**kwargs)	Set options for larray in a controlled context.
get_options()	Return the current options.
labels_array(axes[, title, meta])	Returns an array with specified axes and the combination of corresponding labels as values.
union(*args)	Returns the union of several “value strings” as a list.
stack([elements, axes, title, meta, dtype, …])	Combines several arrays or sessions along an axis.
identity(axis)	
diag(a[, k, axes, ndim, split])	Extracts a diagonal or construct a diagonal array.
eye(rows[, columns, k, title, dtype, meta])	Returns a 2-D array with ones on the diagonal and zeros elsewhere.
ipfp(target_sums[, a, axes, maxiter, …])	Apply Iterative Proportional Fitting Procedure (also known as bi-proportional fitting in statistics, RAS algorithm in economics) to array a, with target_sums as targets.
wrap_elementwise_array_func(func)	Wrap a function using numpy arrays to work with LArray arrays instead.
zip_array_values(values[, axes, ascending])	Returns a sequence as if simultaneously iterating on several arrays.
zip_array_items(values[, axes, ascending])	Returns a sequence as if simultaneously iterating on several arrays as well as the current iteration “key”.

larray.aslarray

larray.**aslarray**(*a*, *meta=None*)
Converts input as LArray if possible.

Parameters

a [array-like] Input array to convert into a LArray.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> # NumPy array
>>> np_arr = np.arange(6).reshape((2,3))
>>> aslarray(np_arr)
{0}*\{1}*  0  1  2
        0  0  1  2
        1  3  4  5
>>> # Pandas dataframe
>>> data = {'normal'  : pd.Series([1., 2., 3.], index=['a', 'b', 'c']),
...         'reverse' : pd.Series([3., 2., 1.], index=['a', 'b', 'c'])}
>>> df = pd.DataFrame(data)
>>> aslarray(df)
{0}\{1}  normal  reverse
      a     1.0      3.0
      b     2.0      2.0
      c     3.0      1.0
```

larray.from_frame

`larray.from_frame`(*df*, *sort_rows=False*, *sort_columns=False*, *parse_header=False*, *unfold_last_axis_name=False*, *fill_value=nan*, *meta=None*, *cartesian_prod=True*, ***kwargs*)

Converts Pandas DataFrame into LArray.

Parameters

df [pandas.DataFrame] Input dataframe. By default, name and labels of the last axis are defined by the name and labels of the columns Index of the dataframe unless argument unfold_last_axis_name is set to True.

sort_rows [bool, optional] Whether or not to sort the rows alphabetically (sorting is more efficient than not sorting). Must be False if *cartesian_prod* is set to True. Defaults to False.

sort_columns [bool, optional] Whether or not to sort the columns alphabetically (sorting is more efficient than not sorting). Must be False if *cartesian_prod* is set to True. Defaults to False.

parse_header [bool, optional] Whether or not to parse columns labels. Pandas treats column labels as strings. If True, column labels are converted into int, float or boolean when possible. Defaults to False.

unfold_last_axis_name [bool, optional] Whether or not to extract the names of the last two axes by splitting the name of the last index column of the dataframe using \. Defaults to False.

fill_value [scalar, optional] Value used to fill cells corresponding to label combinations which are not present in the input DataFrame. Defaults to NaN.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

cartesian_prod [bool, optional] Whether or not to expand the dataframe to a cartesian product dataframe as needed by LArray. This is an expensive operation but is absolutely required if you cannot guarantee your dataframe is already well formed. If True, arguments *sort_rows* and *sort_columns* must be set to False. Defaults to True.

Returns

LArray

See also:

LArray.to_frame

Examples

```
>>> from larray import ndtest
>>> df = ndtest((2, 2, 2)).to_frame()
>>> df
↪ # doctest: +NORMALIZE_WHITESPACE
c       c0  c1
a  b
a0 b0    0   1
   b1    2   3
a1 b0    4   5
   b1    6   7
>>> from_frame(df)
 a  b\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
```

Names of the last two axes written as `before_last_axis_name\\last_axis_name`

```
>>> df = ndtest((2, 2, 2)).to_frame(fold_last_axis_name=True)
>>> df
↪ # doctest: +NORMALIZE_WHITESPACE
        c0  c1
a  b\c
a0 b0    0   1
   b1    2   3
a1 b0    4   5
   b1    6   7
>>> from_frame(df, unfold_last_axis_name=True)
 a  b\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
```

larray.from_series

`larray.`**`from_series`**(*s*, *sort_rows=False*, *fill_value=nan*, *meta=None*, ***kwargs*)
Converts Pandas Series into LArray.

Parameters

s [Pandas Series] Input Pandas Series.

sort_rows [bool, optional] Whether or not to sort the rows alphabetically. Defaults to False.

fill_value [scalar, optional] Value used to fill cells corresponding to label combinations which are not present in the input Series. Defaults to NaN.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

See also:

LArray.to_series

Examples

```
>>> from larray import ndtest
>>> s = ndtest((2, 2, 2), dtype=float).to_series()
>>> s
↪# doctest: +NORMALIZE_WHITESPACE
a   b   c
a0  b0  c0    0.0
        c1    1.0
    b1  c0    2.0
        c1    3.0
a1  b0  c0    4.0
        c1    5.0
    b1  c0    6.0
        c1    7.0
dtype: float64
>>> from_series(s)
 a  b\c   c0   c1
a0   b0  0.0  1.0
a0   b1  2.0  3.0
a1   b0  4.0  5.0
a1   b1  6.0  7.0
```

larray.get_example_filepath

`larray.get_example_filepath(fname)`

Return absolute path to an example file if exist.

Parameters

fname [str] Filename of an existing example file.

Returns

Filepath Absolute filepath to an example file if exists.

Notes

A ValueError is raised if the provided filename does not represent an existing example file.

Examples

```
>>> fpath = get_example_filepath('examples.xlsx')
```

larray.set_options

class larray.**set_options**(***kwargs*)

Set options for larray in a controlled context.

Currently supported options:

- `display_precision`: number of digits of precision for floating point output. Print as many digits as necessary to uniquely specify the value by default (None).
- `display_width`: maximum display width for `repr` on larray objects. Defaults to 80.
- `display_maxlines`: Maximum number of lines to show. All lines are shown if -1. Defaults to 200.
- `display_edgeitems` : if number of lines to display is greater than `display_maxlines`, only the first and last `display_edgeitems` lines are displayed. Only active if `display_maxlines` is not -1. Defaults to 5.

Examples

```
>>> from larray import *
>>> arr = ndtest((500, 100), dtype=float) + 0.123456
```

You can use `set_options` either as a context manager:

```
>>> with set_options(display_width=100, display_edgeitems=2):
...     print(arr)
 a\b          b0           b1           b2  ...          b97          b98 ␣
↪        b99
  a0    0.123456     1.123456     2.123456  ...    97.123456    98.123456 ␣
↪  99.123456
  a1  100.123456   101.123456   102.123456  ...   197.123456   198.123456 ␣
↪ 199.123456
 ...         ...          ...          ...  ...          ...          ... ␣
↪        ...
a498  49800.123456  49801.123456  49802.123456  ...  49897.123456  49898.123456 ␣
↪49899.123456
a499  49900.123456  49901.123456  49902.123456  ...  49997.123456  49998.123456 ␣
↪49999.123456
```

Or to set global options:

```
>>> set_options(display_maxlines=10, display_precision=2) # doctest: +SKIP
>>> print(arr) # doctest: +SKIP
 a\b        b0        b1        b2  ...       b97       b98       b99
  a0      0.12      1.12      2.12  ...     97.12     98.12     99.12
  a1    100.12    101.12    102.12  ...    197.12    198.12    199.12
  a2    200.12    201.12    202.12  ...    297.12    298.12    299.12
  a3    300.12    301.12    302.12  ...    397.12    398.12    399.12
  a4    400.12    401.12    402.12  ...    497.12    498.12    499.12
 ...       ...       ...       ...  ...       ...       ...       ...
a495  49500.12  49501.12  49502.12  ...  49597.12  49598.12  49599.12
```

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```
a496   49600.12  49601.12  49602.12  ...  49697.12  49698.12  49699.12
a497   49700.12  49701.12  49702.12  ...  49797.12  49798.12  49799.12
a498   49800.12  49801.12  49802.12  ...  49897.12  49898.12  49899.12
a499   49900.12  49901.12  49902.12  ...  49997.12  49998.12  49999.12
```

To put back the default options, you can use:

```
>>> set_options(display_precision=None, display_width=80, display_maxlines=200,␣
↪display_edgeitems=5)
... # doctest: +SKIP
```

__init__(*self*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

Methods

__init__(self, **kwargs)	Initialize self.

larray.get_options

larray.**get_options**()
Return the current options.

Returns

Dictionary of current print options with keys

- display_precision: int or None
- display_width: int
- display_maxlines: int
- display_edgeitems : int

For a full description of these options, see *set_options*.

See also:

set_options

Examples

```
>>> get_options() # doctest: +SKIP
{'display_precision': None, 'display_width': 80, 'display_maxlines': 200,
↪'display_edgeitems': 5}
```

larray.labels_array

larray.**labels_array**(*axes*, *title=None*, *meta=None*)
Returns an array with specified axes and the combination of corresponding labels as values.

Parameters

axes [Axis or collection of Axis]

title [str, optional] Deprecated. See 'meta' below.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> labels_array(sex)
sex  M  F
     M  F
>>> labels_array((nat, sex))
nat  sex\axis  nat  sex
 BE         M   BE    M
 BE         F   BE    F
 FO         M   FO    M
 FO         F   FO    F
```

larray.union

`larray.union(*args)`

Returns the union of several "value strings" as a list.

Parameters

***args** (collection of) value(s) to be converted into label(s). Repeated values are taken only once.

Returns

list of labels

Examples

```
>>> union('a', 'a, b, c, d', ['d', 'e', 'f'], '..2')
['a', 'b', 'c', 'd', 'e', 'f', 0, 1, 2]
```

larray.stack

`larray.stack(elements=None, axes=None, title=None, meta=None, dtype=None, res_axes=None, **kwargs)`

Combines several arrays or sessions along an axis.

Parameters

elements [tuple, list or dict.] Elements to stack. Elements can be scalars, arrays, sessions, (label, value) pairs or a {label: value} mapping. In the later case, axis must be defined and cannot be a name only, because we need to have labels order, which the mapping does not provide.

Stacking sessions will return a new session containing the arrays of all sessions stacked together. An array missing in a session will be replaced by NaN.

axes [str, Axis, Group or sequence of Axis, optional] Axes to create. If None, defaults to a range() axis.

title [str, optional] Deprecated. See 'meta' below.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, . . .) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

dtype [type, optional] Output dtype. Defaults to None (inspect all output values to infer it automatically).

res_axes [AxisCollection, optional] Axes of the output. Defaults to None (union of axes of all values and the stacking axes).

Returns

LArray A single array combining arrays. The new (stacked) axes will be the last axes of the new array.

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> arr1 = ones(sex)
>>> arr1
sex    M    F
     1.0  1.0
>>> arr2 = zeros(sex)
>>> arr2
sex    M    F
     0.0  0.0
```

In case the axis to create has already been defined in a variable (Axis or Group)

```
>>> stack({'BE': arr1, 'FO': arr2}, nat)
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
```

Otherwise (when one wants to create an axis from scratch), any of these syntaxes works:

```
>>> stack([arr1, arr2], 'nat=BE,FO')
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
>>> stack({'BE': arr1, 'FO': arr2}, 'nat=BE,FO')
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
>>> stack([('BE', arr1), ('FO', arr2)], 'nat=BE,FO')
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
```

When stacking arrays with different axes, the result has the union of all axes present:

```
>>> stack({'BE': arr1, 'FO': 0}, nat)
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
```

Creating an axis without name nor labels can be done using:

```
>>> stack((arr1, arr2))
sex\{1}*    0    1
       M  1.0  0.0
       F  1.0  0.0
```

When labels are "simple" strings (ie no integers, no string starting with integers, etc.), using keyword arguments can be an attractive alternative.

```
>>> stack(FO=arr2, BE=arr1, axes=nat)
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
```

Without passing an explicit order for labels (or an axis object like above), it should only be used on Python 3.6 or later because keyword arguments are NOT ordered on earlier Python versions.

```
>>> # use this only on Python 3.6 and later
>>> stack(BE=arr1, FO=arr2, axes='nat')   # doctest: +SKIP
sex\nat   BE   FO
      M  1.0  0.0
      F  1.0  0.0
```

One can also stack along several axes

```
>>> test = Axis('test=T1,T2')
>>> stack({('BE', 'T1'): arr1,
...        ('BE', 'T2'): arr2,
...        ('FO', 'T1'): arr2,
...        ('FO', 'T2'): arr1},
...       (nat, test))
sex  nat\test   T1   T2
  M        BE  1.0  0.0
  M        FO  0.0  1.0
  F        BE  1.0  0.0
  F        FO  0.0  1.0
```

To stack sessions, let us first create two test sessions. For example suppose we have a session storing the results of a baseline simulation:

```
>>> from larray import Session
>>> baseline = Session([('arr1', arr1), ('arr2', arr2)])
```

and another session with a variant (here we simply added 0.5 to each array)

```
>>> variant = Session([('arr1', arr1 + 0.5), ('arr2', arr2 + 0.5)])
```

then we stack them together

```
>>> stacked = stack([('baseline', baseline), ('variant', variant)], 'sessions')
>>> stacked
```

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```
Session(arr1, arr2)
>>> stacked.arr1
sex\sessions  baseline  variant
           M       1.0      1.5
           F       1.0      1.5
>>> stacked.arr2
sex\sessions  baseline  variant
           M       0.0      0.5
           F       0.0      0.5
```

larray.identity

`larray.identity(axis)`

larray.diag

`larray.diag(a, k=0, axes=(0, 1), ndim=2, split=True)`

Extracts a diagonal or construct a diagonal array.

Parameters

a [LArray] If *a* has 2 dimensions or more, return a copy of its *k*-th diagonal. If *a* has 1 dimension, return an array with *ndim* dimensions on the *k*-th diagonal.

k [int, optional] Offset of the diagonal from the main diagonal. Can be positive or negative. Defaults to main diagonal (0).

axes [tuple or list or AxisCollection of axes references, optional] Axes along which the diagonals should be taken. Use None for all axes. Defaults to the first two axes (0, 1).

ndim [int, optional] Target number of dimensions when constructing a diagonal array from an array without axes names/labels. Defaults to 2.

split [bool, optional] Whether or not to try to split the axis name and labels. Defaults to True.

Returns

LArray The extracted diagonal or constructed diagonal array.

Examples

```
>>> nat = Axis('nat=BE,FO')
>>> sex = Axis('sex=M,F')
>>> a = ndtest([nat, sex], start=1)
>>> a
nat\sex  M  F
     BE  1  2
     FO  3  4
>>> d = diag(a)
>>> d
nat_sex  BE_M  FO_F
            1     4
>>> diag(d)
nat\sex  M  F
     BE  1  0
```

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```
     FO  0  4
>>> a = ndtest(sex, start=1)
>>> a
sex  M  F
     1  2
>>> diag(a)
sex\sex  M  F
      M  1  0
      F  0  2
```

larray.eye

larray.**eye**(*rows*, *columns=None*, *k=0*, *title=None*, *dtype=None*, *meta=None*)

Returns a 2-D array with ones on the diagonal and zeros elsewhere.

Parameters

rows [int or Axis] Rows of the output.

columns [int or Axis, optional] Columns of the output. If None, defaults to rows.

k [int, optional] Index of the diagonal: 0 (the default) refers to the main diagonal, a positive value refers to an upper diagonal, and a negative value to a lower diagonal.

title [str, optional] Deprecated. See 'meta' below.

dtype [data-type, optional] Data-type of the returned array. Defaults to float.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray of shape (rows, columns) An array where all elements are equal to zero, except for the k-th diagonal, whose values are equal to one.

Examples

```
>>> eye(2, dtype=int)
{0}*\{1}*  0  1
        0  1  0
        1  0  1
>>> sex = Axis('sex=M,F')
>>> eye(sex)
sex\sex    M    F
      M  1.0  0.0
      F  0.0  1.0
>>> age = Axis('age=0..2')
>>> eye(age, sex)
age\sex    M    F
      0  1.0  0.0
      1  0.0  1.0
      2  0.0  0.0
>>> eye(3, k=1)
{0}*\{1}*    0    1    2
```

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```
        0   0.0   1.0   0.0
        1   0.0   0.0   1.0
        2   0.0   0.0   0.0
```

larray.ipfp

larray.**ipfp**(*target_sums*, *a=None*, *axes=None*, *maxiter=1000*, *threshold=0.5*, *stepstoabort=10*, *nzvzs='raise'*, *no_convergence='raise'*, *display_progress=False*)

Apply Iterative Proportional Fitting Procedure (also known as bi-proportional fitting in statistics, RAS algorithm in economics) to array a, with target_sums as targets.

Parameters

target_sums [tuple/list of array-like] Target sums to achieve. First element must be the sum to achieve along axis 0, the second the sum along axis 1, . . .

a [array-like, optional] Starting values to fit, if not given starts with an array filled with 1.

axes [list/tuple of axes, optional] Axes on which the fitting procedure should be applied. Defaults to all axes.

maxiter [int, optional] Maximum number of iteration, defaults to 1000.

threshold [float, optional] Threshold below which the result is deemed acceptable, defaults to 0.5.

stepstoabort [int, optional] Number of consecutive steps with no improvement after which to abort. Defaults to 10.

nzvzs ['fix', 'warn' or 'raise', optional] Behavior when detecting non zero values where the sum is zero 'fix': set to zero (silently) 'warn': set to zero and print a warning 'raise': raise an exception (default)

no_convergence ['ignore', 'warn' or 'raise, optional] Behavior when the algorithm does not seem to converge. This condition is triggered both when the maximum number of iteration is reached or when the maximum absolute difference between the target and the current sums does not improve for *stepstoabort* iterations. 'ignore': return values computed up to that point (silently) 'warn': return values computed up to that point and print a warning 'raise': raise an exception (default)

display_progress [False, True or 'condensed', optional] Whether or not to display progress. Defaults to False. If 'condensed' will display progress using a denser template (using one line per iteration).

Returns

LArray

Examples

```
>>> from larray import *
>>> a = Axis('a=a0,a1')
>>> b = Axis('b=b0,b1')
>>> initial = LArray([[2, 1], [1, 2]], [a, b])
>>> initial
a\b  b0  b1
 a0   2   1
```

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```
 a1   1   2
>>> target_sum_along_a = LArray([2, 1], b)
>>> target_sum_along_a
b  b0  b1
    2   1
>>> target_sum_along_b = LArray([1, 2], a)
>>> target_sum_along_b
a  a0  a1
    1   2
>>> result = ipfp([target_sum_along_a, target_sum_along_b], initial, threshold=0.
↪01)
>>> # round result so that its display is nicer
... round(result, 2)
a\b    b0    b1
 a0  0.85  0.15
 a1  1.15  0.85
```

Now let us assume you have a 3D array like this:

```
>>> year = Axis('year=2014..2016')
>>> initial = ndtest([a, b, year])
>>> initial
 a  b\year  2014  2015  2016
a0      b0     0     1     2
a0      b1     3     4     5
a1      b0     6     7     8
a1      b1     9    10    11
```

and some targets for each year:

```
>>> btargets = initial.sum(X.a) + 1
>>> btargets
b\year  2014  2015  2016
    b0     7     9    11
    b1    13    15    17
>>> atargets = initial.sum(X.b) + 1
>>> atargets
a\year  2014  2015  2016
    a0     4     6     8
    a1    16    18    20
```

You want to apply a 2D fitting procedure for each value of that year axis. You could call ipfp within a loop on the year axis, but you can also apply the procedure for all years at once by using the axes argument. This is *much* faster than an explicit loop.

```
>>> result = ipfp([btargets, atargets], initial, axes=(X.a, X.b))
```

larray.wrap_elementwise_array_func

larray.**wrap_elementwise_array_func**(*func*)

Wrap a function using numpy arrays to work with LArray arrays instead.

Parameters

func [function] A function taking numpy arrays as arguments and returning numpy arrays of the same shape. If the function takes several arguments, this wrapping code assumes the result will have the combination of all axes present. In numpy talk, arguments will be broadcasted to each other.

Returns

function A function taking LArray arguments and returning LArrays.

Examples

For example, if we want to apply the Hodrick-Prescott filter from statsmodels we can use this:

```
>>> from statsmodels.tsa.filters.hp_filter import hpfilter          # doctest:␣
↪+SKIP
>>> hpfilter = wrap_elementwise_array_func(hpfilter)                # doctest:␣
↪+SKIP
```

hpfilter is now a function taking a one dimensional LArray as input and returning a one dimensional LArray as output

Now let us suppose we have a ND array such as:

```
>>> from larray.random import normal
>>> arr = normal(axes="sex=M,F;year=2016..2018")                    # doctest:␣
↪+SKIP
>>> arr                                                             # doctest:␣
↪+SKIP
sex\year   2016   2017   2018
       M  -1.15   0.56  -1.06
       F  -0.48  -0.39  -0.98
```

We can apply an Hodrick-Prescott filter to it by using:

```
>>> # 6.25 is the recommended smoothing value for annual data
>>> cycle, trend = arr.apply(hpfilter, 6.25, axes="year")           # doctest:␣
↪+SKIP
>>> trend                                                           # doctest:␣
↪+SKIP
sex\year   2016   2017   2018
       M  -0.61  -0.52  -0.52
       F  -0.37  -0.61  -0.87
```

larray.zip_array_values

`larray.`**`zip_array_values`**(*values*, *axes=None*, *ascending=True*)

Returns a sequence as if simultaneously iterating on several arrays.

Parameters

axes [int, str or Axis or tuple of them, optional] Axis or axes along which to iterate and in which order. Defaults to None (union of all axes present in all arrays, in the order they are found).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

Returns

Sequence

Examples

```
>>> arr1 = ndtest('a=a0,a1;b=b1,b2')
>>> arr2 = ndtest('a=a0,a1;c=c1,c2')
>>> arr1
a\b  b1  b2
 a0   0   1
 a1   2   3
>>> arr2
a\c  c1  c2
 a0   0   1
 a1   2   3
>>> for a1, a2 in zip_array_values((arr1, arr2), 'a'):
...     print("==")
...     print(a1)
...     print(a2)
==
b  b1  b2
    0   1
c  c1  c2
    0   1
==
b  b1  b2
    2   3
c  c1  c2
    2   3
>>> for a1, a2 in zip_array_values((arr1, arr2), arr2.c):
...     print("==")
...     print(a1)
...     print(a2)
==
a\b  b1  b2
 a0   0   1
 a1   2   3
a  a0  a1
    0   2
==
a\b  b1  b2
 a0   0   1
 a1   2   3
a  a0  a1
    1   3
>>> for a1, a2 in zip_array_values((arr1, arr2)):
...     print("arr1: {}, arr2: {}".format(a1, a2))
arr1: 0, arr2: 0
arr1: 0, arr2: 1
arr1: 1, arr2: 0
arr1: 1, arr2: 1
arr1: 2, arr2: 2
arr1: 2, arr2: 3
arr1: 3, arr2: 2
arr1: 3, arr2: 3
```

larray.zip_array_items

`larray.`**`zip_array_items`**(*values*, *axes=None*, *ascending=True*)

Returns a sequence as if simultaneously iterating on several arrays as well as the current iteration "key".

Broadcasts all values against each other. Scalars are simply repeated.

Parameters

values [Iterable] arrays to iterate on.

axes [int, str or Axis or tuple of them, optional] Axis or axes along which to iterate and in which order. Defaults to None (union of all axes present in all arrays, in the order they are found).

ascending [bool, optional] Whether or not to iterate the axes in ascending order (from start to end). Defaults to True.

Returns

Sequence

Examples

```
>>> arr1 = ndtest('a=a0,a1;b=b0,b1')
>>> arr2 = ndtest('a=a0,a1;c=c0,c1')
>>> arr1
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> arr2
a\c  c0  c1
 a0   0   1
 a1   2   3
>>> for k, (a1, a2) in zip_array_items((arr1, arr2), 'a'):
...     print("==", k[0], "==")
...     print(a1)
...     print(a2)
== a0 ==
b  b0  b1
    0   1
c  c0  c1
    0   1
== a1 ==
b  b0  b1
    2   3
c  c0  c1
    2   3
>>> for k, (a1, a2) in zip_array_items((arr1, arr2), arr2.c):
...     print("==", k[0], "==")
...     print(a1)
...     print(a2)
== c0 ==
a\b  b0  b1
 a0   0   1
 a1   2   3
a  a0  a1
    0   2
== c1 ==
a\b  b0  b1
 a0   0   1
 a1   2   3
a  a0  a1
```

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```
    1   3
>>> for k, (a1, a2) in zip_array_items((arr1, arr2)):
...     print(k, "arr1: {}, arr2: {}".format(a1, a2))
(a.i[0], b.i[0], c.i[0]) arr1: 0, arr2: 0
(a.i[0], b.i[0], c.i[1]) arr1: 0, arr2: 1
(a.i[0], b.i[1], c.i[0]) arr1: 1, arr2: 0
(a.i[0], b.i[1], c.i[1]) arr1: 1, arr2: 1
(a.i[1], b.i[0], c.i[0]) arr1: 2, arr2: 2
(a.i[1], b.i[0], c.i[1]) arr1: 2, arr2: 3
(a.i[1], b.i[1], c.i[0]) arr1: 3, arr2: 2
(a.i[1], b.i[1], c.i[1]) arr1: 3, arr2: 3
```

4.3.13 Session

Session(*args, **kwargs)	Groups several objects together.
arrays([depth, include_private, meta])	Returns a session containing all available arrays (whether they are defined in local or global variables) sorted in alphabetical order.
local_arrays([depth, include_private, meta])	Returns a session containing all local arrays sorted in alphabetical order.
global_arrays([depth, include_private, meta])	Returns a session containing all global arrays sorted in alphabetical order.
load_example_data(name)	Load arrays used in the tutorial so that all examples in it can be reproduced.

larray.Session

class larray.**Session**(**args*, ***kwargs*)

Groups several objects together.

Parameters

***args** [str or dict of {str: object} or iterable of tuples (str, object)] Path to the file containing the session to load or list/tuple/dictionary containing couples (name, object).

****kwargs** [dict of {str: object}]

- Objects to add written as name=object
- **meta** [list of pairs or dict or OrderedDict or Metadata] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

> **Warning:** Metadata is not kept when actions or methods are applied on a session except for operations modifying a specific array, such as: *s['arr1'] = 0*. Do not add metadata to a session if you know you will apply actions or methods on it before dumping it.

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)
```

create a Session by passing a list of pairs (name, object)

```
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])
```

create a Session using keyword arguments (but you lose order on Python < 3.6)

```
>>> s = Session(a=a, b=b, a01=a01, arr1=arr1, arr2=arr2)
```

create a Session by passing a dictionary (but you lose order on Python < 3.6)

```
>>> s = Session({'a': a, 'b': b, 'a01': a01, 'arr1': arr1, 'arr2': arr2})
```

load Session from file

```
>>> s = Session('my_session.h5')  # doctest: +SKIP
```

create a session with metadata

```
>>> # Python <= 3.5
>>> s = Session([('arr1', arr1), ('arr2', arr2)], meta=[('title', 'my title'), (
↪'author', 'John Smith')])
>>> s.meta
title: my title
author: John Smith
>>> # Python 3.6+
>>> s = Session(arr1=arr1, arr2=arr2, meta=Metadata(title='my title', author=
↪'John Smith'))  # doctest: +SKIP
>>> s.meta
title: my title
author: John Smith
```

__init__(*self*, **args*, ***kwargs*)
Initialize self. See help(type(self)) for accurate signature.

Methods

`__init__`(self, *args, **kwargs)	Initialize self.
`add`(self, *args, **kwargs)	Adds objects to the current session.
`apply`(self, func, *args, **kwargs)	Apply function *func* on elements of the session and return a new session.
`array_equals`(*args, **kwargs)	
`compact`(self[, display])	Detects and removes "useless" axes (ie axes for which values are constant over the whole axis) for all array objects in session
`copy`(self)	Returns a copy of the session.
`dump`(*args, **kwargs)	

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dump_csv(*args, **kwargs)	
dump_excel(*args, **kwargs)	
dump_hdf(*args, **kwargs)	
element_equals(self, other)	Test if each element (group, axis and array) of the current session equals the corresponding element of another session.
equals(self, other)	Test if all elements (groups, axes and arrays) of the current session are equal to those of another session.
filter(self[, pattern, kind])	Returns a new session with objects which match some criteria.
get(self, key[, default])	Returns the object corresponding to the key.
items(self)	Returns a view of the session's items ((key, value) pairs).
keys(self)	Returns a view on the session's keys.
load(self, fname[, names, engine, display])	Load LArray, Axis and Group objects from a file, or several .csv files.
save(self, fname[, names, engine, …])	Dumps LArray, Axis and Group objects from the current session to a file.
summary(self[, template])	Returns a summary of the content of the session.
to_csv(self, fname[, names, display])	Dumps LArray, Axis and Group objects from the current session to CSV files.
to_excel(self, fname[, names, overwrite, …])	Dumps LArray, Axis and Group objects from the current session to an Excel file.
to_globals(self[, names, depth, warn, inplace])	Create global variables out of objects in the session.
to_hdf(self, fname[, names, overwrite, display])	Dumps LArray, Axis and Group objects from the current session to an HDF file.
to_pickle(self, fname[, names, overwrite, …])	Dumps LArray, Axis and Group objects from the current session to a file using pickle.
transpose(self, *args)	Reorder axes of arrays in session, ignoring missing axes for each array.
update(self[, other])	Update the session with the key/value pairs from other or passed keyword arguments, overwriting existing keys.
values(self)	Returns a view on the session's values.

Attributes

names	Returns the list of names of the objects in the session.

larray.arrays

larray.**arrays**(*depth=0*, *include_private=False*, *meta=None*)

Returns a session containing all available arrays (whether they are defined in local or global variables) sorted in alphabetical order. Local arrays take precedence over global ones (if a name corresponds to both a local and a global variable, the local array will be returned).

Parameters

depth: int depth of call frame to inspect. 0 is where *arrays* was called, 1 the caller of *arrays*, etc.

include_private: boolean, optional Whether or not to include private arrays (i.e. arrays starting with _). Defaults to False.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

Session

larray.local_arrays

`larray.local_arrays(depth=0, include_private=False, meta=None)`

Returns a session containing all local arrays sorted in alphabetical order.

Parameters

depth: int depth of call frame to inspect. 0 is where *local_arrays* was called, 1 the caller of *local_arrays*, etc.

include_private: boolean, optional Whether or not to include private local arrays (i.e. arrays starting with _). Defaults to False.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

Session

larray.global_arrays

`larray.global_arrays(depth=0, include_private=False, meta=None)`

Returns a session containing all global arrays sorted in alphabetical order.

Parameters

depth: int depth of call frame to inspect. 0 is where *global_arrays* was called, 1 the caller of *global_arrays*, etc.

include_private: boolean, optional Whether or not to include private globals arrays (i.e. arrays starting with _). Defaults to False.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, ...) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

Session

larray.load_example_data

`larray.load_example_data(name)`

Load arrays used in the tutorial so that all examples in it can be reproduced.

Parameters

name [str] Example data to load. Available example datasets are:

- demography

Returns

Session Session containing one or several arrays

Examples

```
>>> demo = load_example_data('demography')
>>> demo.pop.info # doctest: +SKIP
26 x 3 x 121 x 2 x 2
 time [26]: 1991 1992 1993 ... 2014 2015 2016
 geo [3]: 'BruCap' 'Fla' 'Wal'
 age [121]: 0 1 2 ... 118 119 120
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
>>> demo.qx.info # doctest: +SKIP
26 x 3 x 121 x 2 x 2
 time [26]: 1991 1992 1993 ... 2014 2015 2016
 geo [3]: 'BruCap' 'Fla' 'Wal'
 age [121]: 0 1 2 ... 118 119 120
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
```

Exploring

Session.names	Returns the list of names of the objects in the session.
Session.keys(self)	Returns a view on the session's keys.
Session.values(self)	Returns a view on the session's values.
Session.items(self)	Returns a view of the session's items ((key, value) pairs).
Session.summary(self[, template])	Returns a summary of the content of the session.

larray.Session.names

property Session.**names**

Returns the list of names of the objects in the session. The list is sorted alphabetically and does not follow the internal order.

Returns

list of str

See also:

Session.keys

Examples

```
>>> axis1 = Axis("a=a0..a2")
>>> group1 = axis1['a0,a1'] >> 'a01'
>>> arr1, arr2 = ndtest((2, 2)), ndtest(4)
```

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```
>>> s = Session([('arr2', arr2), ('arr1', arr1), ('group1', group1), ('axis1',
↪axis1)])
>>> # print array's names in the alphabetical order
>>> s.names
['arr1', 'arr2', 'axis1', 'group1']
```

```
>>> # keys() follows the internal order
>>> list(s.keys())
['arr2', 'arr1', 'group1', 'axis1']
```

larray.Session.keys

`Session.keys(self)`

Returns a view on the session's keys.

Returns

View on the session's keys.

See also:

Session.names

Examples

```
>>> axis1 = Axis("a=a0..a2")
>>> group1 = axis1['a0,a1'] >> 'a01'
>>> arr1, arr2 = ndtest((2, 2)), ndtest(4)
>>> s = Session([('arr2', arr2), ('arr1', arr1), ('group1', group1), ('axis1',
↪axis1)])
>>> # similar to names by follows the internal order
>>> list(s.keys())
['arr2', 'arr1', 'group1', 'axis1']
```

```
>>> # gives the names of objects in alphabetical order
>>> s.names
['arr1', 'arr2', 'axis1', 'group1']
```

larray.Session.values

`Session.values(self)`

Returns a view on the session's values.

Returns

View on the session's values.

Examples

```
>>> axis1 = Axis("a=a0..a2")
>>> group1 = axis1['a0,a1'] >> 'a01'
>>> arr1, arr2 = ndtest((2, 2)), ndtest(4)
>>> s = Session([('arr2', arr2), ('arr1', arr1), ('group1', group1), ('axis1',␣
↪axis1)])
>>> # assuming you know the order of objects stored in the session
>>> arr2, arr1, group1, axis1 = s.values()
>>> # otherwise, prefer the following syntax
>>> arr1, arr2, axis1, group1 = s['arr1', 'arr2', 'axis1', 'group1']
>>> arr1
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> axis1
Axis(['a0', 'a1', 'a2'], 'a')
```

larray.Session.items

Session.**items**(*self*)

Returns a view of the session's items ((key, value) pairs).

Returns

View on the session's items.

Examples

```
>>> axis1 = Axis("a=a0..a2")
>>> group1 = axis1['a0,a1'] >> 'a01'
>>> arr1, arr2 = ndtest((2, 2)), ndtest(4)
>>> # make the test pass on both Windows and Linux
>>> arr1, arr2 = arr1.astype(np.int64), arr2.astype(np.int64)
>>> s = Session([('arr2', arr2), ('arr1', arr1), ('group1', group1), ('axis1',␣
↪axis1)])
>>> for k, v in s.items():
...     print("{}: {}".format(k, v.info if isinstance(v, LArray) else repr(v)))
arr2: 4
 a [4]: 'a0' 'a1' 'a2' 'a3'
dtype: int64
memory used: 32 bytes
arr1: 2 x 2
 a [2]: 'a0' 'a1'
 b [2]: 'b0' 'b1'
dtype: int64
memory used: 32 bytes
group1: a['a0', 'a1'] >> 'a01'
axis1: Axis(['a0', 'a1', 'a2'], 'a')
```

larray.Session.summary

Session.**summary**(*self*, *template=None*)

Returns a summary of the content of the session.

Parameters

template: dict {object type: str} or dict {object type: func} Template describing how items and metadata are summarized. For each object type, it is possible to provide either a string template or a function taking the the key and value of a session item as parameters and returning a string (see examples). A string template contains specific arguments written inside brackets {}. Available arguments are:

- for groups: 'key', 'name', 'axis_name', 'labels' and 'length',
- for axes: 'key', 'name', 'labels' and 'length',
- for arrays: 'key', 'axes_names', 'shape', 'dtype' and 'title',
- for session metadata: 'key', 'value',
- for all other types: 'key', 'value'.

Returns

str Short representation of the content of the session.

Examples

```
>>> axis1 = Axis("a=a0..a2")
>>> group1 = axis1['a0,a1'] >> 'a01'
>>> arr1 = ndtest((2, 2), dtype=np.int64, meta=[('title', 'array 1')])
>>> arr2 = ndtest(4, dtype=np.int64, meta=[('title', 'array 2')])
>>> arr3 = ndtest((3, 2), dtype=np.int64, meta=[('title', 'array 3')])
>>> s = Session([('axis1', axis1), ('group1', group1), ('arr1', arr1), ('arr2',␣
↪arr2), ('arr3', arr3)])
>>> s.meta.title = 'my title'
>>> s.meta.author = 'John Smith'
```

Default template

```
>>> print(s.summary())  # doctest: +NORMALIZE_WHITESPACE
Metadata:
    title: my title
    author: John Smith
axis1: a ['a0' 'a1' 'a2'] (3)
group1: a['a0', 'a1'] >> a01 (2)
arr1: a, b (2 x 2) [int64]
arr2: a (4) [int64]
arr3: a, b (3 x 2) [int64]
```

Using a specific template

```
>>> def print_array(key, array):
...     axes_names = ', '.join(array.axes.display_names)
...     shape = ' x '.join(str(i) for i in array.shape)
...     return "{} -> {} ({})\n  title = {}\n  dtype = {}".format(key, axes_names,
↪ shape,
...                                                                 array.meta.
↪title, array.dtype)
>>> template = {Axis:  "{key} -> {name} [{labels}] ({length})",
...             Group: "{key} -> {name}: {axis_name}{labels} ({length})",
...             LArray: print_array,
...             Metadata: "\t{key} -> {value}"}
>>> print(s.summary(template))   # doctest: +NORMALIZE_WHITESPACE
Metadata:
```

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```
    title -> my title
    author -> John Smith
axis1 -> a ['a0' 'a1' 'a2'] (3)
group1 -> a01: a['a0', 'a1'] (2)
arr1 -> a, b (2 x 2)
  title = array 1
  dtype = int64
arr2 -> a (4)
  title = array 2
  dtype = int64
arr3 -> a, b (3 x 2)
  title = array 3
  dtype = int64
```

Copying

Session.copy(self)	Returns a copy of the session.

larray.Session.copy

Session.**copy**(*self*)

Returns a copy of the session.

Testing

Session.element_equals(self, other)	Test if each element (group, axis and array) of the current session equals the corresponding element of another session.
Session.equals(self, other)	Test if all elements (groups, axes and arrays) of the current session are equal to those of another session.

larray.Session.element_equals

Session.**element_equals**(*self*, *other*)

Test if each element (group, axis and array) of the current session equals the corresponding element of another session.

For arrays, it is equivalent to apply *LArray.equals()* with flag nans_equal=True to all arrays from two sessions.

Parameters

other [Session] Session to compare with.

Returns

Boolean LArray

See also:

Session.equals

Notes

Metadata is ignored.

Examples

```
>>> a = Axis('a=a0..a2')
>>> a01 = a['a0,a1'] >> 'a01'
>>> s1 = Session([('a', a), ('a01', a01), ('arr1', ndtest(2)), ('arr2', ndtest((2,
↪ 2)))])
>>> s2 = Session([('a', a), ('a01', a01), ('arr1', ndtest(2)), ('arr2', ndtest((2,
↪ 2)))])
```

Identical sessions

```
>>> s1.element_equals(s2)
name      a    a01   arr1   arr2
       True   True   True   True
```

Different value(s) between two arrays

```
>>> s2.arr1['a1'] = 0
>>> s1.element_equals(s2)
name      a    a01    arr1   arr2
       True   True   False   True
```

Different label(s)

```
>>> s2.arr2 = ndtest("b=b0,b1; a=a0,a1")
>>> s2.a = Axis('a=a0,a1')
>>> s1.element_equals(s2)
name       a    a01    arr1    arr2
       False   True   False   False
```

Extra/missing objects

```
>>> s2.arr3 = ndtest((3, 3))
>>> del s2.a
>>> s1.element_equals(s2)
name       a    a01    arr1    arr2    arr3
       False   True   False   False   False
```

larray.Session.equals

`Session.`**`equals`**(*self*, *other*)

Test if all elements (groups, axes and arrays) of the current session are equal to those of another session.

Parameters

other [Session] Session to compare with.

Returns

True if elements of both sessions are all equal, False otherwise.

See also:

Session.element_equals

Notes

Metadata is ignored.

Examples

```
>>> a = Axis('a=a0..a2')
>>> a01 = a['a0,a1'] >> 'a01'
>>> s1 = Session([('a', a), ('a01', a01), ('arr1', ndtest(2)), ('arr2', ndtest((2,
↪ 2)))])
>>> s2 = Session([('a', a), ('a01', a01), ('arr1', ndtest(2)), ('arr2', ndtest((2,
↪ 2)))])
```

Identical sessions

```
>>> s1.equals(s2)
True
```

Different value(s) between two arrays

```
>>> s2.arr1['a1'] = 0
>>> s1.equals(s2)
False
```

Different label(s)

```
>>> s2.arr2 = ndtest("b=b0,b1; a=a0,a1")
>>> s2.a = Axis('a=a0,a1')
>>> s1.equals(s2)
False
```

Extra/missing axis(es), group(s), array(s)

```
>>> s2.arr3 = ndtest((3, 3))
>>> del s2.a
>>> s1.equals(s2)
False
```

Selecting

Session.get(self, key[, default])	Returns the object corresponding to the key.

larray.Session.get

Session.**get**(*self*, *key*, *default=None*)

Returns the object corresponding to the key. If the key doesn't correspond to any object, a default one can be returned.

Parameters

key [str] Name of the object.

default [object, optional] Returned object if the key doesn't correspond to any object of the current session.

Returns

object Object corresponding to the given key or a default one if not found.

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',
↪arr2)])
>>> arr = s.get('arr1')
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
 a2   6   7   8
>>> arr = s.get('arr4', zeros('a=a0,a1;b=b0,b1', dtype=int))
>>> arr
a\b  b0  b1
 a0   0   0
 a1   0   0
```

Modifying

`Session.add`(self, *args, **kwargs)	Adds objects to the current session.
`Session.update`(self[, other])	Update the session with the key/value pairs from other or passed keyword arguments, overwriting existing keys.
`Session.get`(self, key[, default])	Returns the object corresponding to the key.
`Session.apply`(self, func, *args, **kwargs)	Apply function *func* on elements of the session and return a new session.
`Session.transpose`(self, *args)	Reorder axes of arrays in session, ignoring missing axes for each array.

larray.Session.add

`Session.`**add**(*self*, **args*, ***kwargs*)

Adds objects to the current session.

Parameters

***args** [list of object] Objects to add. Objects must have an attribute 'name'.

****kwargs** [dict of {str: object}] Objects to add written as name=array, …

Examples

```
>>> s = Session()
>>> axis1, axis2 = Axis('x=x0..x2'), Axis('y=y0..y2')
>>> arr1, arr2, arr3 = ndtest((2, 2)), ndtest(4), ndtest((3, 2))
>>> s.add(axis1, axis2, arr1=arr1, arr2=arr2, arr3=arr3)
>>> # print item's names in sorted order
>>> s.names
['arr1', 'arr2', 'arr3', 'x', 'y']
```

larray.Session.update

`Session.update`(*self*, *other=None*, ***kwargs*)

Update the session with the key/value pairs from other or passed keyword arguments, overwriting existing keys. Note that the session is updated inplace and no new Session object is returned.

Parameters

other: Session or dict-like object or iterable with key/value pairs Object containing key/value pairs to add or modify.

****kwargs:** If keyword arguments are specified, the session is then updated with those key/value pairs (e.g.: ses.update(pop=pop, births=births, deaths=deaths)).

Examples

```
>>> x, y = Axis('x=x0..x2'), Axis('y=y0..y3')
>>> arr1 = ndtest((x, y))
>>> arr2 = ndtest(x)
>>> s = Session(x=x, y=y, arr1=arr1, arr2=arr2)
>>> # print item's names in sorted order
>>> s.names
['arr1', 'arr2', 'x', 'y']
>>> s.arr2
x  x0  x1  x2
    0   1   2
```

```
>>> # new axis and array
>>> z = Axis('z=z0..z2')
>>> arr3 = ndtest((x, z))
>>> # arr2 is modified
>>> arr2_modified = arr2.set_axes('x', z)
```

Passing another session

```
>>> s2 = Session(z=z, arr2=arr2_modified, arr3=arr3)
>>> s.names
['arr1', 'arr2', 'x', 'y']
>>> s.arr2
x  x0  x1  x2
    0   1   2
>>> s.update(s2)
>>> # new items have been added to the session 's'
>>> s.names
```

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```
['arr1', 'arr2', 'arr3', 'x', 'y', 'z']
>>> # and array 'arr2' has been updated
>>> s.arr2
z  z0  z1  z2
    0   1   2
```

Passing a dictionary

```
>>> s = Session(x=x, y=y, arr1=arr1, arr2=arr2)
>>> s.names
['arr1', 'arr2', 'x', 'y']
>>> s.arr2
x  x0  x1  x2
    0   1   2
>>> d = {'z': z, 'arr2': arr2_modified, 'arr3': arr3}
>>> s.update(d)
>>> s.names
['arr1', 'arr2', 'arr3', 'x', 'y', 'z']
>>> s.arr2
z  z0  z1  z2
    0   1   2
```

Passing an iterable with key/value pairs

```
>>> s = Session(x=x, y=y, arr1=arr1, arr2=arr2)
>>> s.names
['arr1', 'arr2', 'x', 'y']
>>> s.arr2
x  x0  x1  x2
    0   1   2
>>> i = [('z', z), ('arr2', arr2_modified), ('arr3', arr3)]
>>> s.update(i)
>>> s.names
['arr1', 'arr2', 'arr3', 'x', 'y', 'z']
>>> s.arr2
z  z0  z1  z2
    0   1   2
```

Passing keyword arguments

```
>>> s = Session(x=x, y=y, arr1=arr1, arr2=arr2)
>>> s.names
['arr1', 'arr2', 'x', 'y']
>>> s.arr2
x  x0  x1  x2
    0   1   2
>>> s.update(z=z, arr2=arr2_modified, arr3=arr3)
>>> s.names
['arr1', 'arr2', 'arr3', 'x', 'y', 'z']
>>> s.arr2
z  z0  z1  z2
    0   1   2
```

larray.Session.apply

Session.**apply**(*self*, *func*, **args*, ***kwargs*)

Apply function *func* on elements of the session and return a new session.

Parameters

func [function] Function to apply to each element of the session. It should take a single *element* argument and return a single value.

***args** [any] Any extra arguments are passed to the function

kind [type or tuple of types, optional] Type(s) of elements *func* will be applied to. Other elements will be left intact. Use ´kind=object´ to apply to all kinds of objects. Defaults to LArray.

****kwargs** [any] Any extra keyword arguments are passed to the function

Returns

Session A new session containing all processed elements

Examples

```
>>> arr1 = ndtest(2)
>>> arr1
a  a0  a1
    0   1
>>> arr2 = ndtest(3)
>>> arr2
a  a0  a1  a2
    0   1   2
>>> sess1 = Session([('arr1', arr1), ('arr2', arr2)])
>>> sess1
Session(arr1, arr2)
>>> def increment(array):
...     return array + 1
>>> sess2 = sess1.apply(increment)
>>> sess2.arr1
a  a0  a1
    1   2
>>> sess2.arr2
a  a0  a1  a2
    1   2   3
```

You may also pass extra arguments or keyword arguments to the function

```
>>> def change(array, increment=1, multiplier=1):
...     return (array + increment) * multiplier
>>> sess2 = sess1.apply(change, 2, 2)
>>> sess2 = sess1.apply(change, 2, multiplier=2)
>>> sess2.arr1
a  a0  a1
    4   6
>>> sess2.arr2
a  a0  a1  a2
    4   6   8
```

larray.Session.transpose

Session.**transpose**(*self*, **args*)

Reorder axes of arrays in session, ignoring missing axes for each array.

Parameters

***args** Accepts either a tuple of axes specs or axes specs as **args*. Omitted axes keep their order. Use ... to avoid specifying intermediate axes. Axes missing in an array are ignored.

Returns

Session Session with each array with reordered axes where appropriate.

See also:

LArray.transpose

Examples

Let us create a test session and a small helper function to display sessions as a short summary.

```
>>> arr1 = ndtest((2, 2, 2))
>>> arr2 = ndtest((2, 2))
>>> sess = Session([('arr1', arr1), ('arr2', arr2)])
>>> def print_summary(s):
...     print(s.summary({LArray: "{key} -> {axes_names}"}))
>>> print_summary(sess)
arr1 -> a, b, c
arr2 -> a, b
```

Put 'b' axis in front of all arrays

```
>>> print_summary(sess.transpose('b'))
arr1 -> b, a, c
arr2 -> b, a
```

Axes missing on an array are ignored ('c' for arr2 in this case)

```
>>> print_summary(sess.transpose('c', 'b'))
arr1 -> c, b, a
arr2 -> b, a
```

Use ... to move axes to the end

```
>>> print_summary(sess.transpose(..., 'a'))   # doctest: +SKIP
arr1 -> b, c, a
arr2 -> b, a
```

Filtering/Cleaning

Session.filter(self[, pattern, kind])	Returns a new session with objects which match some criteria.

Continued on next page

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Session.compact(self[, display])	Detects and removes “useless” axes (ie axes for which values are constant over the whole axis) for all array objects in session

larray.Session.filter

Session.**filter**(*self*, *pattern=None*, *kind=None*)
Returns a new session with objects which match some criteria.

Parameters

pattern [str, optional] Only keep arrays whose key match *pattern*.

- *?* matches any single character
- * matches any number of characters
- [seq] matches any character in seq
- [!seq] matches any character not in seq

kind [(tuple of) type, optional] Only keep objects which are instances of type(s) *kind*.

Returns

Session The filtered session.

Examples

```
>>> axis = Axis('a=a0..a2')
>>> group = axis['a0,a1'] >> 'a01'
>>> test1, zero1 = ndtest((2, 2)), zeros((3, 2))
>>> s = Session([('test1', test1), ('zero1', zero1), ('axis', axis), ('group',
↪group)])
```

Filter using a pattern argument

```
>>> # get all items with names ending with '1'
>>> s.filter(pattern='*1').names
['test1', 'zero1']
```

```
>>> # get all items with names starting with letter in range a-k
>>> s.filter(pattern='[a-k]*').names
['axis', 'group']
```

Filter using kind argument

```
>>> s.filter(kind=Axis).names
['axis']
>>> s.filter(kind=(Axis, Group)).names
['axis', 'group']
```

larray.Session.compact

Session.**compact**(*self*, *display=False*)
Detects and removes “useless” axes (ie axes for which values are constant over the whole axis) for all array

objects in session

Parameters

display [bool, optional] Whether or not to display a message for each array that is compacted

Returns

Session A new session containing all compacted arrays

Examples

```
>>> arr1 = sequence('b=b0..b2', ndtest(3), zeros_like(ndtest(3)))
>>> arr1
a\b  b0  b1  b2
 a0   0   0   0
 a1   1   1   1
 a2   2   2   2
>>> compact_ses = Session(arr1=arr1).compact(display=True)
arr1 was constant over {b}
>>> compact_ses.arr1
a  a0  a1  a2
    0   1   2
```

Load/Save

`Session.load`(self, fname[, names, engine, ...])	Load LArray, Axis and Group objects from a file, or several .csv files.
`Session.save`(self, fname[, names, engine, ...])	Dumps LArray, Axis and Group objects from the current session to a file.
`Session.to_csv`(self, fname[, names, display])	Dumps LArray, Axis and Group objects from the current session to CSV files.
`Session.to_excel`(self, fname[, names, ...])	Dumps LArray, Axis and Group objects from the current session to an Excel file.
`Session.to_hdf`(self, fname[, names, ...])	Dumps LArray, Axis and Group objects from the current session to an HDF file.
`Session.to_pickle`(self, fname[, names, ...])	Dumps LArray, Axis and Group objects from the current session to a file using pickle.

larray.Session.load

`Session.`**`load`**(*self*, *fname*, *names=None*, *engine='auto'*, *display=False*, ***kwargs*)

Load LArray, Axis and Group objects from a file, or several .csv files.

WARNING: never load a file using the pickle engine (.pkl or .pickle) from an untrusted source, as it can lead to arbitrary code execution.

Parameters

fname [str] This can be either the path to a single file, a path to a directory containing .csv files or a pattern representing several .csv files.

names [list of str, optional] List of objects to load. If *fname* is None, list of paths to CSV files. Defaults to all valid objects present in the file/directory.

engine [{'auto', 'pandas_csv', 'pandas_hdf', 'pandas_excel', 'xlwings_excel', 'pickle'}, optional] Load using *engine*. Defaults to 'auto' (use default engine for the format guessed from the file extension).

display [bool, optional] Whether or not to display which file is being worked on. Defaults to False.

Examples

In one module:

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")     # doctest: +SKIP
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'                    # doctest: +SKIP
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)       # doctest: +SKIP
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])  # doctest: +SKIP
>>> # metadata
>>> s.meta.title = 'my title'                    # doctest: +SKIP
>>> s.meta.author = 'John Smith'                 # doctest: +SKIP
>>> # save the session in an HDF5 file
>>> s.save('input.h5')                           # doctest: +SKIP
```

In another module: load the whole session

```
>>> # the load method is automatically called when passing
>>> # the path of file to the Session constructor
>>> s = Session('input.h5')      # doctest: +SKIP
>>> s                            # doctest: +SKIP
Session(a, b, a01, arr1, arr2)
>>> s.meta                       # doctest: +SKIP
title: my title
author: John Smith
```

Load only some objects

```
>>> s = Session()                                   # doctest: +SKIP
>>> s.load('input.h5', ['a', 'b', 'arr1', 'arr2'])  # doctest: +SKIP
>>> a, b, arr1, arr2 = s['a', 'b', 'arr1', 'arr2']  # doctest: +SKIP
>>> # only if you know the order of arrays stored in session
>>> a, b, a01, arr1, arr2 = s.values()              # doctest: +SKIP
```

Using .csv files (assuming the same session as above)

```
>>> s.save('data')                                # doctest: +SKIP
>>> s = Session()                                 # doctest: +SKIP
>>> # load all .csv files starting with "output" in the data directory
>>> s.load('data')                                # doctest: +SKIP
>>> # or only arrays (i.e. all CSV files starting with 'arr')
>>> s.load('data/arr*.csv')                       # doctest: +SKIP
```

larray.Session.save

`Session.save(self, fname, names=None, engine='auto', overwrite=True, display=False, **kwargs)`

Dumps LArray, Axis and Group objects from the current session to a file.

Parameters

fname [str] Path of the file for the dump. If objects are saved in CSV files, the path corresponds to a directory.

names [list of str or None, optional] List of names of LArray/Axis/Group objects to dump. If *fname* is None, list of paths to CSV files. Defaults to all objects present in the Session.

engine [{'auto', 'pandas_csv', 'pandas_hdf', 'pandas_excel', 'xlwings_excel', 'pickle'}, optional] Dump using *engine*. Defaults to 'auto' (use default engine for the format guessed from the file extension).

overwrite: bool, optional Whether or not to overwrite an existing file, if any. Ignored for CSV files and 'pandas_excel' engine. If False, file is updated. Defaults to True.

display [bool, optional] Whether or not to display which file is being worked on. Defaults to False.

Notes

See Notes section from `to_csv()` and `to_excel()`.

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")     # doctest: +SKIP
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'                     # doctest: +SKIP
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)        # doctest: +SKIP
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])  # doctest: +SKIP
>>> # metadata
>>> s.meta.title = 'my title'                     # doctest: +SKIP
>>> s.meta.author = 'John Smith'                  # doctest: +SKIP
```

Save all objects

```
>>> s.save('output.h5')                              # doctest: +SKIP
```

Save only some objects

```
>>> s.save('output.h5', ['a', 'b', 'arr1'])          # doctest: +SKIP
```

Update file

```
>>> arr1, arr4 = ndtest((3, 3)), ndtest((2, 3))      # doctest: +SKIP
>>> s2 = Session([('arr1', arr1), ('arr4', arr4)])   # doctest: +SKIP
>>> # replace arr1 and add arr4 in file output.h5
>>> s2.save('output.h5', overwrite=False)            # doctest: +SKIP
```

larray.Session.to_csv

`Session.to_csv(self, fname, names=None, display=False, **kwargs)`

Dumps LArray, Axis and Group objects from the current session to CSV files.

Parameters

fname [str] Path for the directory that will contain CSV files.

names [list of str or None, optional] Names of LArray/Axis/Group objects to dump. Defaults to all objects present in the Session.

display [bool, optional] Whether or not to display which file is being worked on. Defaults to False.

Notes

- each array is saved in a separate file
- all Axis objects are saved together in the same CSV file named __axes__.csv
- all Group objects are saved together in the same CSV file named __groups__.csv
- all session metadata is saved in the same CSV file named __metadata__.csv

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")     # doctest: +SKIP
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'                      # doctest: +SKIP
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)         # doctest: +SKIP
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])  # doctest: +SKIP
>>> # metadata
>>> s.meta.title = 'my title'                      # doctest: +SKIP
>>> s.meta.author = 'John Smith'                   # doctest: +SKIP
```

Save all arrays

```
>>> s.to_csv('./Output')  # doctest: +SKIP
```

Save only some arrays

```
>>> s.to_csv('./Output', ['a', 'b', 'arr1'])  # doctest: +SKIP
```

larray.Session.to_excel

`Session.to_excel(self, fname, names=None, overwrite=True, display=False, **kwargs)`

Dumps LArray, Axis and Group objects from the current session to an Excel file.

Parameters

fname [str] Path of the file for the dump.

names [list of str or None, optional] Names of LArray/Axis/Group objects to dump. Defaults to all objects present in the Session.

overwrite: bool, optional Whether or not to overwrite an existing file, if any. If False, file is updated. Defaults to True.

display [bool, optional] Whether or not to display which file is being worked on. Defaults to False.

Notes

- each array is saved in a separate sheet
- all Axis objects are saved together in the same sheet named __axes__
- all Group objects are saved together in the same sheet named __groups__
- all session metadata is saved in the same sheet named __metadata__

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")     # doctest: +SKIP
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'                     # doctest: +SKIP
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)        # doctest: +SKIP
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',
↪arr2)])  # doctest: +SKIP
>>> # metadata
>>> s.meta.title = 'my title'                     # doctest: +SKIP
>>> s.meta.author = 'John Smith'                  # doctest: +SKIP
```

Save all arrays

```
>>> s.to_excel('output.xlsx')  # doctest: +SKIP
```

Save only some objects

```
>>> s.to_excel('output.xlsx', ['a', 'b', 'arr1'])  # doctest: +SKIP
```

larray.Session.to_hdf

`Session.to_hdf`(*self*, *fname*, *names=None*, *overwrite=True*, *display=False*, ***kwargs*)

Dumps LArray, Axis and Group objects from the current session to an HDF file.

Parameters

fname [str] Path of the file for the dump.

names [list of str or None, optional] Names of LArray/Axis/Group objects to dump. Defaults to all objects present in the Session.

overwrite: bool, optional Whether or not to overwrite an existing file, if any. If False, file is updated. Defaults to True.

display [bool, optional] Whether or not to display which file is being worked on. Defaults to False.

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")     # doctest: +SKIP
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'                     # doctest: +SKIP
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)        # doctest: +SKIP
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])  # doctest: +SKIP
>>> # metadata
>>> s.meta.title = 'my title'                     # doctest: +SKIP
>>> s.meta.author = 'John Smith'                  # doctest: +SKIP
```

Save all arrays

```
>>> s.to_hdf('output.h5')  # doctest: +SKIP
```

Save only some objects

```
>>> s.to_hdf('output.h5', ['a', 'b', 'arr1'])  # doctest: +SKIP
```

larray.Session.to_pickle

`Session.`**`to_pickle`**(*self*, *fname*, *names=None*, *overwrite=True*, *display=False*, ***kwargs*)

Dumps LArray, Axis and Group objects from the current session to a file using pickle.

WARNING: never load a pickle file (.pkl or .pickle) from an untrusted source, as it can lead to arbitrary code execution.

Parameters

fname [str] Path for the dump.

names [list of str or None, optional] Names of LArray/Axis/Group objects to dump. Defaults to all objects present in the Session.

overwrite: bool, optional Whether or not to overwrite an existing file, if any. If False, file is updated. Defaults to True.

display [bool, optional] Whether or not to display which file is being worked on. Defaults to False.

Examples

```
>>> # axes
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")     # doctest: +SKIP
>>> # groups
>>> a01 = a['a0,a1'] >> 'a01'                     # doctest: +SKIP
>>> # arrays
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)        # doctest: +SKIP
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])  # doctest: +SKIP
>>> # metadata
>>> s.meta.title = 'my title'                     # doctest: +SKIP
>>> s.meta.author = 'John Smith'                  # doctest: +SKIP
```

Save all arrays

```
>>> s.to_pickle('output.pkl')   # doctest: +SKIP
```

Save only some objects

```
>>> s.to_pickle('output.pkl', ['a', 'b', 'arr1'])   # doctest: +SKIP
```

4.3.14 Editor

view([obj, title, depth])	Opens a new viewer window.
edit([obj, title, minvalue, maxvalue, ...])	Opens a new editor window.
compare(*args, **kwargs)	Opens a new comparator window, comparing arrays or sessions.

larray.view

larray.**view**(*obj=None*, *title="*, *depth=0*)

Opens a new viewer window. Arrays are loaded in readonly mode and their content cannot be modified.

Parameters

obj [np.ndarray, LArray, Session, dict or str, optional] Object to visualize. If string, array(s) will be loaded from the file given as argument. Defaults to the collection of all local variables where the function was called.

title [str, optional] Title for the current object. Defaults to the name of the first object found in the caller namespace which corresponds to *obj* (it will use a combination of the 3 first names if several names correspond to the same object).

depth [int, optional] Stack depth where to look for variables. Defaults to 0 (where this function was called).

Examples

```
>>> a1 = ndtest(3)
↪                   # doctest: +SKIP
>>> a2 = ndtest(3) + 1
↪                   # doctest: +SKIP
>>> # will open a viewer showing all the arrays available at this point
>>> # (a1 and a2 in this case)
>>> view()
↪                   # doctest: +SKIP
>>> # will open a viewer showing only a1
>>> view(a1)
↪                   # doctest: +SKIP
```

larray.edit

larray.**edit**(*obj=None*, *title="*, *minvalue=None*, *maxvalue=None*, *readonly=False*, *depth=0*)

Opens a new editor window.

Parameters

obj [np.ndarray, LArray, Session, dict, str or REOPEN_LAST_FILE, optional] Object to visualize. If string, array(s) will be loaded from the file given as argument. Passing the constant REOPEN_LAST_FILE loads the last opened file. Defaults to the collection of all local variables where the function was called.

title [str, optional] Title for the current object. Defaults to the name of the first object found in the caller namespace which corresponds to *obj* (it will use a combination of the 3 first names if several names correspond to the same object).

minvalue [scalar, optional] Minimum value allowed.

maxvalue [scalar, optional] Maximum value allowed.

readonly [bool, optional] Whether or not editing array values is forbidden. Defaults to False.

depth [int, optional] Stack depth where to look for variables. Defaults to 0 (where this function was called).

Examples

```
>>> a1 = ndtest(3)                                                              # doctest: +SKIP
>>> a2 = ndtest(3) + 1                                                          # doctest: +SKIP
>>> # will open an editor with all the arrays available at this point
>>> # (a1 and a2 in this case)
>>> edit()                                                                      # doctest: +SKIP
>>> # will open an editor for a1 only
>>> edit(a1)                                                                    # doctest: +SKIP
```

larray.compare

`larray.compare(*args, **kwargs)`

Opens a new comparator window, comparing arrays or sessions.

Parameters

***args** [LArrays or Sessions] Arrays or sessions to compare.

title [str, optional] Title for the window. Defaults to ‘’.

names [list of str, optional] Names for arrays or sessions being compared. Defaults to the name of the first objects found in the caller namespace which correspond to the passed objects.

depth [int, optional] Stack depth where to look for variables. Defaults to 0 (where this function was called).

Examples

```
>>> a1 = ndtest(3)                                                              # doctest: +SKIP
>>> a2 = ndtest(3) + 1                                                          # doctest: +SKIP
```

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```
>>> compare(a1, a2, title='first comparison')                                    ␣
↪                 # doctest: +SKIP
>>> compare(a1 + 1, a2, title='second comparison', names=['a1+1', 'a2'])        ␣
↪                 # doctest: +SKIP
```

4.3.15 Random

`random.randint`(low[, high, axes, dtype, meta])	Return random integers from *low* (inclusive) to *high* (exclusive).
`random.normal`([loc, scale, axes, meta])	Draw random samples from a normal (Gaussian) distribution.
`random.uniform`([low, high, axes, meta])	Draw samples from a uniform distribution.
`random.permutation`(x[, axis])	Randomly permute a sequence along an axis, or return a permuted range.
`random.choice`([choices, axes, replace, p, meta])	Generates a random sample from given choices

larray.random.randint

larray.random.**randint**(*low*, *high=None*, *axes=None*, *dtype='l'*, *meta=None*)

Return random integers from *low* (inclusive) to *high* (exclusive).

Return random integers from the "discrete uniform" distribution of the specified dtype in the "half-open" interval [*low*, *high*). If *high* is None (the default), then results are from [0, *low*).

Parameters

low [int] Lowest (signed) integer to be drawn from the distribution (unless `high=None`, in which case this parameter is one above the *highest* such integer).

high [int, optional] If provided, one above the largest (signed) integer to be drawn from the distribution (see above for behavior if `high=None`).

axes [int, tuple of int, str, Axis or tuple/list/AxisCollection of Axis, optional] Axes (or shape) of the resulting array. If `axes` is None (the default), a single value is returned. Otherwise, if the resulting axes have a shape of, e.g., `(m, n, k)`, then `m * n * k` samples are drawn.

dtype [data-type, optional] Desired dtype of the result. All dtypes are determined by their name, i.e., 'int64', 'int', etc, so byteorder is not available and a specific precision may have different C types depending on the platform. The default value is 'np.int'.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray

Examples

Generate a single int between 0 and 9, inclusive:

```
>>> la.random.randint(10)                                    # doctest: +SKIP
6
```

Generate an array of 10 ints between 1 and 5, inclusive:

```
>>> la.random.randint(1, 6, 10)                              # doctest: +SKIP
{0}*   0   1   2   3   4   5   6   7   8   9
       1   1   5   1   5   4   3   4   2   1
```

Generate a 2 x 3 array of ints between 0 and 4, inclusive:

```
>>> la.random.randint(5, axes=(2, 3))                        # doctest: +SKIP
{0}*\{1}*   0   1   2
        0   4   4   1
        1   1   2   2
>>> la.random.randint(5, axes='a=a0,a1;b=b0..b2')           # doctest: +SKIP
a\b  b0  b1  b2
 a0   0   3   1
 a1   4   0   1
```

larray.random.normal

`larray.random.normal` (*loc=0.0*, *scale=1.0*, *axes=None*, *meta=None*)

Draw random samples from a normal (Gaussian) distribution.

Its probability density function is often called the bell curve because of its characteristic shape (see the example below)

Parameters

loc [float or array_like of floats] Mean ("centre") of the distribution.

scale [float or array_like of floats] Standard deviation (spread or "width") of the distribution.

axes [int, tuple of int, str, Axis or tuple/list/AxisCollection of Axis, optional] Minimum axes the resulting array must have. Defaults to None. The resulting array axes will be the union of those mentioned in `axes` and those of `loc` and `scale`. If `loc` and `scale` are scalars and `axes` is None, a single value is returned. Otherwise, if the resulting axes have a shape of, e.g., `(m, n, k)`, then `m * n * k` samples are drawn.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray or scalar Drawn samples from the parameterized normal distribution.

Notes

The normal distributions occurs often in nature. For example, it describes the commonly occurring distribution of samples influenced by a large number of tiny, random disturbances, each with its own unique distribution [2].

The probability density function for the Gaussian distribution, first derived by De Moivre and 200 years later by both Gauss and Laplace independently [2], is

$$p(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}},$$

where μ is the mean and σ the standard deviation. The square of the standard deviation, σ^2, is called the variance.

The function has its peak at the mean, and its "spread" increases with the standard deviation (the function reaches 0.607 times its maximum at $x + \sigma$ and $x - \sigma$ [2]). This implies that *la.random.normal* is more likely to return samples lying close to the mean, rather than those far away.

References

[1], [2]

Examples

Generate a 2 x 3 array with numbers drawn from the distribution:

```
>>> la.random.normal(0, 1, axes=(2, 3))                                           #␣
↪doctest: +SKIP
{0}*\{1}*                  0                     1                   2
        0  0.3564325741877542    0.8944149721039006  1.7206904920773107
        1  0.6904447654719367  -0.09395966570976753   0.185136309092257
```

With named and labelled axes

```
>>> la.random.normal(0, 1, axes='a=a0,a1;b=b0..b2')                               #␣
↪doctest: +SKIP
a\b                 b0                    b1                    b2
 a0   2.3096106652701827  -0.4269082412118316  -1.0862791566867225
 a1   0.8598817639620348   -2.386411240813283  0.10116503197279443
```

With varying loc and scale (each depending on a different axis)

```
>>> a = la.Axis('a=a0,a1')
>>> b = la.Axis('b=b0..b2')
>>> mu = la.sequence(a, initial=5, inc=5)
>>> mu
a  a0  a1
    5  10
>>> sigma = la.sequence(b, initial=1)
>>> sigma
b  b0  b1  b2
    1   2   3
>>> la.random.normal(mu, sigma)                                                   #␣
↪doctest: +SKIP
a\b                  b0                   b1                   b2
 a0    5.939369790854615   2.5043856460438403     8.33560126941519
 a1   10.759526714752091   10.093213549397403   11.705881778249683
```

Draw 1000 samples from the distribution:

```
>>> mu, sigma = 0, 0.1  # mean and standard deviation
>>> sample = la.random.normal(mu, sigma, 1000)
```

Verify the mean and the variance:

```
>>> abs(mu - la.mean(sample)) < 0.01
True
>>> abs(sigma - la.std(sample, ddof=1)) < 0.01
True
```

Display the histogram of the samples, along with the probability density function:

```
>>> import matplotlib.pyplot as plt                                        #␣
↪doctest: +SKIP
>>> count, bins, ignored = plt.hist(sample, 30, normed=True)               #␣
↪doctest: +SKIP
>>> pdf = 1 / (sigma * la.sqrt(2 * la.pi)) \
...         * la.exp(- (bins - mu) ** 2 / (2 * sigma ** 2))               #␣
↪doctest: +SKIP
>>> _ = plt.plot(bins, pdf, linewidth=2, color='r')                        #␣
↪doctest: +SKIP
>>> plt.show()                                                             #␣
↪doctest: +SKIP
```

larray.random.uniform

`larray.random.uniform`(*low=0.0*, *high=1.0*, *axes=None*, *meta=None*)

Draw samples from a uniform distribution.

Samples are uniformly distributed over the half-open interval `[low, high)` (includes low, but excludes high). In other words, any value within the given interval is equally likely to be drawn by *uniform*.

Parameters

low [float or array_like of floats, optional] Lower boundary of the output interval. All values generated will be greater than or equal to low. Defaults to 0.0.

high [float or array_like of floats, optional] Upper boundary of the output interval. All values generated will be less than high. Defaults to 1.0.

axes [int, tuple of int, str, Axis or tuple/list/AxisCollection of Axis, optional] Minimum axes the resulting array must have. Defaults to None. The resulting array axes will be the union of those mentioned in `axes` and those of `low` and `high`. If `low` and `high` are scalars and `axes` is None, a single value is returned. Otherwise, if the resulting axes have a shape of, e.g., `(m, n, k)`, then `m * n * k` samples are drawn.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, …) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray or scalar Drawn samples from the parameterized uniform distribution.

See also:

randint Discrete uniform distribution, yielding integers.

Notes

The probability density function of the uniform distribution is

$$p(x) = \frac{1}{b - a}$$

anywhere within the interval `[a, b)`, and zero elsewhere.

When `high` == `low`, values of `low` will be returned. If `high` < `low`, the results are officially undefined and may eventually raise an error, i.e. do not rely on this function to behave when passed arguments satisfying that inequality condition.

Examples

Generate a single sample from the distribution:

```
>>> la.random.uniform()
↪# doctest: +SKIP
0.4616049008844396
```

Generate a 2 x 3 array with numbers drawn from the distribution:

```
>>> la.random.uniform(0, 5, axes=(2, 3))
↪# doctest: +SKIP
{0}*\{1}*                   0                   1                   2
        0  3.4951791043804192  3.888533056628081  4.347461073315136
        1   2.146211610940853  0.509146487437932  2.790852715735223
```

With named and labelled axes

```
>>> la.random.uniform(1, 2, axes='a=a0,a1;b=b0..b2')
↪# doctest: +SKIP
a\b                  b0                  b1                  b2
 a0  1.4167729850467825  1.6953091052066793  1.2321770607672526
 a1  1.4386221912579358  1.8480607144284926  1.1726213637670433
```

With varying low and high (each depending on a different axis)

```
>>> a = la.Axis('a=a0,a1')
>>> b = la.Axis('b=b0..b2')
>>> low = la.sequence(a)
>>> low
a  a0  a1
    0   1
>>> high = la.sequence(b, initial=1, inc=0.5)
>>> high
b   b0   b1   b2
   1.0  1.5  2.0
>>> la.random.uniform(low, high)
↪# doctest: +SKIP
a\b                   b0                  b1                  b2
 a0  0.44608671494167573   0.948315996350121    1.74189664009661
 a1                  1.0  1.1099944474264194  1.1362792569316835
```

Draw 1000 samples from the distribution:

```
>>> s = la.random.uniform(-1, 0, 1000)
```

All values are within the given interval:

```
>>> la.all(s >= -1)
True
```

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```
>>> la.all(s < 0)
True
```

Display the histogram of the samples, along with the probability density function:

```
>>> import matplotlib.pyplot as plt                                    #␣
↪doctest: +SKIP
>>> count, bins, ignored = plt.hist(s, 15, normed=True)               #␣
↪doctest: +SKIP
>>> _ = plt.plot(bins, np.ones_like(bins), linewidth=2, color='r')    #␣
↪doctest: +SKIP
>>> plt.show()                                                         #␣
↪doctest: +SKIP
```

larray.random.permutation

`larray.random.permutation(x, axis=0)`

Randomly permute a sequence along an axis, or return a permuted range.

Parameters

x [int or array_like] If *x* is an integer, randomly permute `sequence(x)`. If *x* is an array, returns a randomly shuffled copy.

axis [int, str or Axis, optional] Axis along which to permute. Defaults to the first axis.

Returns

LArray Permuted sequence or array range.

Examples

```
>>> la.random.permutation(10)                                  # doctest: +SKIP
{0}*  0  1  2  3  4  5  6  7  8  9
      6  8  0  9  4  7  1  5  3  2
>>> la.random.permutation([1, 4, 9, 12, 15])                   # doctest: +SKIP
{0}*  0   1   2  3  4
      1  15  12  9  4
>>> la.random.permutation(la.ndtest(5))                        # doctest: +SKIP
a  a3  a1  a2  a4  a0
    3   1   2   4   0
>>> arr = la.ndtest((3, 3))                                    # doctest: +SKIP
>>> la.random.permutation(arr)                                 # doctest: +SKIP
a\b  b0  b1  b2
 a1   3   4   5
 a2   6   7   8
 a0   0   1   2
>>> la.random.permutation(arr, axis='b')                       # doctest: +SKIP
a\b  b1  b2  b0
 a0   1   2   0
 a1   4   5   3
 a2   7   8   6
```

larray.random.choice

larray.random.**choice**(*choices=None*, *axes=None*, *replace=True*, *p=None*, *meta=None*)
Generates a random sample from given choices

Parameters

choices [1-D array-like or int, optional] Values to choose from. If an array, a random sample is generated from its elements. If an int n, the random sample is generated as if choices was la.sequence(n) If p is a 1-D LArray, choices are taken from its axis.

axes [int, tuple of int, str, Axis or tuple/list/AxisCollection of Axis, optional] Axes (or shape) of the resulting array. If `axes` is None (the default), a single value is returned. Otherwise, if the resulting axes have a shape of, e.g., `(m, n, k)`, then `m * n * k` samples are drawn.

replace [boolean, optional] Whether the sample is with or without replacement.

p [array-like, optional] The probabilities associated with each entry in choices. If p is a 1-D LArray, choices are taken from its axis labels. If p is an N-D LArray, each cell represents the probability that the combination of labels will occur. If not given the sample assumes a uniform distribution over all entries in choices.

meta [list of pairs or dict or OrderedDict or Metadata, optional] Metadata (title, description, author, creation_date, . . .) associated with the array. Keys must be strings. Values must be of type string, int, float, date, time or datetime.

Returns

LArray or scalar The generated random samples with given `axes` (or shape).

Raises

ValueError If choices is an int and less than zero, if choices or p are not 1-dimensional, if choices is an array-like of size 0, if p is not a vector of probabilities, if choices and p have different lengths, or if replace=False and the sample size is greater than the population size.

See also:

randint, *permutation*

Examples

Generate one random value out of given choices (each choice has the same probability of occurring):

```
>>> la.random.choice(['hello', 'world', '!'])                               
↪  # doctest: +SKIP
hello
```

With given probabilities:

```
>>> la.random.choice(['hello', 'world', '!'], p=[0.1, 0.8, 0.1])           
↪  # doctest: +SKIP
world
```

Generate a 2 x 3 array with given axes and values drawn from the given choices using given probabilities:

```
>>> la.random.choice([5, 10, 15], p=[0.3, 0.5, 0.2], axes='a=a0,a1;b=b0..b2')
↪ # doctest: +SKIP
a\b  b0  b1  b2
 a0  15  10  10
 a1  10   5  10
```

Same as above with labels and probabilities given as a one dimensional LArray

```
>>> proba = LArray([0.3, 0.5, 0.2], Axis([5, 10, 15], 'outcome'))
↪ # doctest: +SKIP
>>> proba
↪ # doctest: +SKIP
outcome    5   10   15
         0.3  0.5  0.2
>>> choice(p=proba, axes='a=a0,a1;b=b0..b2')
↪ # doctest: +SKIP
a\b  b0  b1  b2
 a0  10  15   5
 a1  10   5  10
```

Generate a uniform random sample of size 3 from la.sequence(5):

```
>>> la.random.choice(5, 3)
↪ # doctest: +SKIP
{0}*   0  1  2
       3  2  0
>>> # This is equivalent to la.random.randint(0, 5, 3)
```

Generate a non-uniform random sample of size 3 from the given choices without replacement:

```
>>> la.random.choice(['hello', 'world', '!'], 3, replace=False, p=[0.1, 0.6, 0.
↪3])  # doctest: +SKIP
{0}*       0  1      2
       world  !  hello
```

Using an N-dimensional array as probabilities:

```
>>> proba = LArray([[0.15, 0.25, 0.10],
...                 [0.20, 0.10, 0.20]], 'a=a0,a1;b=b0..b2')
↪ # doctest: +SKIP
>>> proba
↪ # doctest: +SKIP
a\b    b0    b1   b2
 a0  0.15  0.25  0.1
 a1   0.2   0.1  0.2
>>> choice(p=proba, axes='draw=d0..d5')
↪ # doctest: +SKIP
draw\axis   a   b
       d0  a1  b2
       d1  a1  b1
       d2  a0  b1
       d3  a0  b0
       d4  a1  b2
       d5  a0  b1
```

4.3.16 Constants

nan	NaN (Not a Number)
inf	∞ (infinite)
pi	π
e	e
euler_gamma	Euler's γ

larray.core.constants.nan

larray.core.constants.**nan = nan**

NaN (Not a Number)

larray.core.constants.inf

larray.core.constants.**inf = inf**

∞ (infinite)

larray.core.constants.pi

larray.core.constants.**pi = 3.141592653589793**

π

larray.core.constants.e

larray.core.constants.**e = 2.718281828459045**

e

larray.core.constants.euler_gamma

larray.core.constants.**euler_gamma = 0.5772156649015329**

Euler's γ

CHAPTER FIVE

INDICES AND TABLES

- genindex
- modindex
- search

CHAPTER

SIX

APPENDIX

6.1 Change log

6.1.1 Version 0.31

In development.

Syntax changes

- renamed `LArray.old_method_name()` to `LArray.new_method_name()` (closes issue 1).
- renamed `old_argument_name` argument of `LArray.method_name()` to `new_argument_name`.

Backward incompatible changes

- other backward incompatible changes

New features

- added the *ExcelReport* class allowing to generate multiple graphs in an Excel file at once (closes issue 676).

Miscellaneous improvements

- improved something.

Fixes

- fixed something (closes issue 1).

6.1.2 Version 0.30

Released on 2019-06-27.

Syntax changes

- *stack()* axis argument was renamed to axes to reflect the fact that the function can now stack along multiple axes at once (see below).
- to accommodate for the "simpler pattern language" now supported for those functions, using a regular expression in *Axis.matching()* or Group.matching() now requires passing the pattern as an explicit regex keyword argument instead of just the first argument of those methods. For example my_axis.matching('test.*') becomes my_axis.matching(regex='test.*').
- LArray.as_table() is deprecated because it duplicated functionality found in *LArray.dump()*. Please only use *LArray.dump()* from now on.
- renamed a_min and a_max arguments of *LArray.clip()* to minval and maxval respectively and made them optional (closes issue 747).

Backward incompatible changes

- modified the behavior of the pattern argument of *Session.filter()* to actually support patterns instead of only checking if the object names start with the pattern. Special characters include ? for matching any single character and * for matching any number of characters. Closes issue 703.

> **Warning:** If you were using Session.filter, you must add a * to your pattern to keep your code working. For example, my_session.filter('test') must be changed to my_session.filter('test*').

- *LArray.equals()* now returns True for arrays even when axes are in a different order or some axes are missing on either side (but the data is constant over that axis on the other side). Closes issue 237.

> **Warning:** If you were using *LArray.equals()* **and** want to keep the old, stricter, behavior, you must add check_axes=True.

New features

- added *set_options()* and *get_options()* functions to respectively set and get options for larray. Available options currently include display_precision for controlling the number of decimal digits used when showing floating point numbers, display_maxlines to control the maximum number of lines to use when displaying an array, etc. *set_options()* can used either like a normal function to set the options globally or within a with block to set them only temporarily. Closes issue 274.
- implemented *read_stata()* and *LArray.to_stata()* to read arrays from and write arrays to Stata .dta files.
- implemented *LArray.isin()* method to check whether each value of an array is contained in a list (or array) of values.
- implemented *LArray.unique()* method to compute unique values (or sub-arrays) for an array, optionally along axes.
- implemented *LArray.apply()* method to apply a python function to all values of an array or to all sub-arrays along some axes of an array and return the result. This is an extremely versatile method as it can be used both with aggregating functions or element-wise functions.
- implemented *LArray.apply_map()* method to apply a transformation mapping to array elements. For example, this can be used to transform some numeric codes to labels.

- implemented `LArray.reverse()` method to reverse one or several axes of an array (closes issue 631).
- implemented `LArray.roll()` method to roll the cells of an array n-times to the right along an axis. This is similar to `LArray.shift()`, except that cells which are pushed "outside of the axis" are reintroduced on the opposite side of the axis instead of being dropped.
- implemented `Axis.apply()` method to transform an axis labels by a function and return a new Axis.
- added `Session.update()` method to add and modify items from an existing session by passing either another session or a dict-like object or an iterable object with (key, value) pairs (closes issue 754).
- implemented `AxisCollection.rename()` to rename axes of an AxisCollection, independently of any array.
- implemented `AxisCollection.set_labels()` (closes issue 782).
- implemented `wrap_elementwise_array_func()` function to make a function defined in another library work with LArray arguments instead of with numpy arrays.
- implemented `LArray.keys()`, `LArray.values()` and `LArray.items()` methods to respectively loop on an array labels, values or (key, value) pairs.
- implemented `zip_array_values()` and `zip_array_items()` to loop respectively on several arrays values or (key, value) pairs.
- implemented `AxisCollection.iter_labels()` to iterate over all (possible combinations of) labels of the axes of the collection.

Miscellaneous improvements

- improved speed of `read_hdf()` function when reading a stored LArray object dumped with the current and future version of larray. To get benefit of the speedup of reading arrays dumped with older versions of larray, please read and re-dump them. Closes issue 563.
- allowed to not specify the axes in `LArray.set_labels()` (closes issue 634):

```
>>> a = ndtest('nat=BE,FO;sex=M,F')
>>> a
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> a.set_labels({'M': 'Men', 'BE': 'Belgian'})
nat\sex  Men  F
Belgian    0  1
     FO    2  3
```

- `LArray.set_labels()` can now take functions to transform axes labels (closes issue 536).

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> arr.set_labels('a', str.upper)
a\b  b0  b1
 A0   0   1
 A1   2   3
```

- implemented the same "simpler pattern language" in `Axis.matching()` and `Group.matching()` than in `Session.filter()`, in addition to regular expressions (which now require using the `regexp` argument).

- py:obj:*stack()* can now stack along several axes at once (closes issue 56).

```
>>> country = Axis('country=BE,FR,DE')
>>> gender = Axis('gender=M,F')
>>> stack({('BE', 'M'): 0,
...        ('BE', 'F'): 1,
...        ('FR', 'M'): 2,
...        ('FR', 'F'): 3,
...        ('DE', 'M'): 4,
...        ('DE', 'F'): 5},
...       (country, gender))
country\gender  M  F
            BE  0  1
            FR  2  3
            DE  4  5
```

- py:obj:*stack()* using a dictionary as elements can now use a simple axis name instead of requiring a full axis object. This will print a warning on Python < 3.7 though because the ordering of labels is not guaranteed in that case. Closes issue 755 and issue 581.
- py:obj:*stack()* using keyword arguments can now use a simple axis name instead of requiring a full axis object, even on Python < 3.6. This will print a warning though because the ordering of labels is not guaranteed in that case.
- added password argument to `Workbook.save()` to allow protecting Excel files with a password.
- added option `exact` to `join` argument of `Axis.align()` and `LArray.align()` methods. Instead of aligning, passing `join='exact'` to the `align` method will raise an error when axes are not equal. Closes issue 338.
- made `Axis.by()` and `Group.by()` return a list of named groups instead of anonymous groups. By default, group names are defined as `<start>:<end>`. This can be changed via the new `template` argument:

```
>>> age = Axis('age=0..6')
>>> age
Axis([0, 1, 2, 3, 4, 5, 6], 'age')
>>> age.by(3)
(age.i[0:3] >> '0:2', age.i[3:6] >> '3:5', age.i[6:7] >> '6')
>>> age.by(3, step=2)
(age.i[0:3] >> '0:2', age.i[2:5] >> '2:4', age.i[4:7] >> '4:6', age.i[6:7] >> '6')
>>> age.by(3, template='{start}-{end}')
(age.i[0:3] >> '0-2', age.i[3:6] >> '3-5', age.i[6:7] >> '6')
```

  Closes issue 669.

- allowed to specify an axis by its position when selecting a subset of an array using the string notation:

```
>>> pop_mouv = ndtest('geo_from=BE,FR,UK;geo_to=BE,FR,UK')
>>> pop_mouv
geo_from\geo_to  BE  FR  UK
             BE   0   1   2
             FR   3   4   5
             UK   6   7   8
>>> pop_mouv['0[BE, UK]']   # equivalent to pop_mouv[pop_mouv.geo_from['BE,UK']]
geo_from\geo_to  BE  FR  UK
             BE   0   1   2
             UK   6   7   8
>>> pop_mouv['1.i[0, 2]']   # equivalent to pop_mouv[pop_mouv.geo_to.i[0, 2]]
geo_from\geo_to  BE  UK
```

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```
            BE    0    2
            FR    3    5
            UK    6    8
```

Closes issue 671.

- added documentation and examples for *where()*, *maximum()* and *minimum()* functions (closes issue 700)
- updated the `Working With Sessions` section of the tutorial (closes issue 568).
- added dtype argument to LArray to set the type of the array explicitly instead of relying on auto-detection.
- added dtype argument to stack to set the type of the resulting array explicitly instead of relying on auto-detection.
- allowed to pass a single axis or group as `axes_to_reindex` argument of the *LArray.reindex()* method (closes issue 712).
- *LArray.dump()* gained a few extra arguments to further customize output : - axes_names : to specify whether or not the output should contain the axes names (and which) - maxlines and edgeitems : to dump only the start and end of large arrays - light : to output axes labels only when they change instead of repeating them on each line - na_repr : to specify how to represent N/A (NaN) values
- substantially improved performance of creating, iterating, and doing a few other operations over larray objects. This solves a few pathological cases of slow operations, especially those involving many small-ish arrays but sadly the overall performance improvement is negligible over most of the real-world models using larray that we tested these changes on.

Fixes

- fixed dumping to Excel arrays of "object" dtype containing NaN values using numpy float types (fixes the infamous 65535 bug).
- fixed *LArray.divnot0()* being slow when the divisor has many axes and many zeros (closes issue 705).
- fixed maximum length of sheet names (31 characters instead of 30 characters) when adding a new sheet to an Excel Workbook (closes issue 713).
- fixed missing documentation of many functions in *Utility Functions* section of the API Reference (closes issue 698).
- fixed arithmetic operations between two sessions returning a nan value for each axis and group (closes issue 725).
- fixed dumping sessions with metadata in HDF format (closes issue 702).
- fixed minimum version of pandas to install. The minimum version is now 0.20.0.
- fixed from_frame for dataframes with non string index names.
- fixed creating an LSet from an IGroup with a (single) scalar key

```
>>> a = Axis('a=a0,a1,a2')
>>> a.i[1].set()
a['a1'].set()
```

6.1.3 Version 0.29

Released on 2018-09-07.

- deprecated `title` attribute of `LArray` objects and `title` argument of array creation functions. A title is now considered as a metadata and must be added as:

```
>>> # add title at array creation
>>> arr = ndtest((3, 3), meta=[('title', 'array for testing')])
```

```
>>> # or after array creation
>>> arr = ndtest((3, 3))
>>> arr.meta.title = 'array for testing'
```

  See below for more information about metadata handling.

- renamed `LArray.drop_labels()` to *LArray.ignore_labels()* to avoid confusion with the new *LArray.drop()* method (closes issue 672).
- renamed `Session.array_equals()` to *Session.element_equals()* because this method now also compares axes and groups in addition to arrays.
- renamed `Sheet.load()` and `Range.load()` `nb_index` argument to `nb_axes` to be consistent with all other input functions (read_*). `Sheet` and `Range` are the objects one gets when taking subsets of the excel *Workbook* objects obtained via *open_excel()* (closes issue 648).
- deprecated the `element_equal()` function in favor of the *LArray.eq()* method (closes issue 630) to be consistent with other future methods for operations between two arrays.
- renamed `nan_equals` argument of *LArray.equals()* and *LArray.eq()* methods to `nans_equal` because it is grammatically more correct and is explained more naturally as "whether two nans should be considered equal".
- *LArray.insert()* `pos` and `axis` arguments are deprecated because those were only useful for very specific cases and those can easily be rewritten by using an indices group (`axis.i[pos]`) for the `before` argument instead (closes issue 652).
- allowed arrays to have metadata (e.g. title, description, authors, …).

  Metadata can be added when creating arrays:

```
>>> # for Python <= 3.5
>>> arr = ndtest((3, 3), meta=[('title', 'array for testing'), ('author', 'John Smith')])
```

```
>>> # for Python >= 3.6
>>> arr = ndtest((3, 3), meta=Metadata(title='array for testing', author='John Smith'))
```

  To access all existing metadata, use `array.meta`, for example:

```
>>> arr.meta
title: array for testing
author: John Smith
```

  To access some specific existing metadata, use `array.meta.<name>`, for example:

```
>>> arr.meta.author
'John Smith'
```

  Updating some existing metadata, or creating new metadata (the metadata is added if there was no metadata using that name) should be done using `array.meta.<name> = <value>`. For example:

```
>>> arr.meta.city = 'London'
```

To remove some metadata, use `del array.meta.<name>`, for example:

```
>>> del arr.meta.city
```

Note:

- Currently, only the HDF (.h5) file format supports saving and loading array metadata.
- Metadata is not kept when actions or methods are applied on an array except for operations modifying the object in-place, such as *pop[age < 10] = 0*, and when the method *copy()* is called. Do not add metadata to an array if you know you will apply actions or methods on it before dumping it.

Closes issue 78 and issue 79.

- allowed sessions to have metadata. Session metadata is created and accessed **using the same syntax than for arrays** (`session.meta.<name>`), for example to add metadata to a session at creation:

```
>>> # Python <= 3.5
>>> s = Session([('arr1', ndtest(2)), ('arr2', ndtest(3)], meta=[('title', 'my␣
↪title'), ('author', 'John Smith')])
```

```
>>> # Python 3.6+
>>> s = Session(arr1=ndtest(2), arr2=ndtest(3), meta=Metadata(title='my title',␣
↪author='John Smith'))
```

Note:

- Contrary to array metadata, saving and loading session metadata is supported for all current session file formats: Excel, CSV and HDF (.h5)
- Metadata is not kept when actions or methods are applied on a session except for operations modifying a specific array, such as: *s['arr1'] = 0*. Do not add metadata to a session if you know you will apply actions or methods on it before dumping it.

Closes issue 640.

- implemented *LArray.drop()* to return an array without some labels or indices along an axis (closes issue 506).

```
>>> arr1 = ndtest((2, 4))
>>> arr1
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
>>> a, b = arr1.axes
```

Dropping a single label

```
>>> arr1.drop('b1')
a\b  b0  b2  b3
 a0   0   2   3
 a1   4   6   7
```

Dropping multiple labels

```
>>> # arr1.drop('b1,b3')
>>> arr1.drop(['b1', 'b3'])
a\b  b0  b2
 a0   0   2
 a1   4   6
```

Dropping a slice

```
>>> # arr1.drop('b1:b3')
>>> arr1.drop(b['b1':'b3'])
a\b  b0
 a0   0
 a1   4
```

Dropping labels by position requires to specify the axis

```
>>> # arr1.drop('b.i[1]')
>>> arr1.drop(b.i[1])
a\b  b0  b2  b3
 a0   0   2   3
 a1   4   6   7
```

- added new module to create arrays with values generated randomly following a few different distributions, or shuffle an existing array along an axis:

```
>>> from larray.random import *
```

Generate integers between two bounds (0 and 10 in this example)

```
>>> randint(0, 10, axes='a=a0..a2')
a  a0  a1  a2
    3   6   2
```

Generate values following a uniform distribution

```
>>> uniform(axes='a=a0..a2')
a                   a0                  a1                  a2
   0.33293756929238394  0.5331412592583252  0.6748786766763107
```

Generate values following a normal distribution (μ = 1 and σ = 2 in this example)

```
>>> normal(1, scale=2, axes='a=a0..a2')
a                   a0                 a1                  a2
   -0.9216651561025018  5.119734598931103  4.4467876992838935
```

Randomly shuffle an existing array along one axis

```
>>> arr = ndtest((3, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
 a2   6   7   8
>>> permutation(arr, axis='b')
a\b  b1  b2  b0
 a0   1   2   0
```

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```
 a1   4   5   3
 a2   7   8   6
```

Generate values by randomly choosing between specified values (5, 10 and 15 in this example), potentially with a specified probability for each value (respectively a 30%, 50%, 20% probability of occurring in this example).

```
>>> choice([5, 10, 15], p=[0.3, 0.5, 0.2], axes='a=a0,a1;b=b0..b2')
a\b  b0  b1  b2
 a0  15  10  10
 a1  10   5  10
```

Same as above with labels and probabilities given as a one dimensional LArray

```
>>> proba = LArray([0.3, 0.5, 0.2], Axis([5, 10, 15], 'outcome'))
>>> proba
outcome    5   10   15
         0.3  0.5  0.2
>>> choice(p=proba, axes='a=a0,a1;b=b0..b2')
a\b  b0  b1  b2
 a0  10  15   5
 a1  10   5  10
```

- made a few useful constants accessible directly from the larray module: `nan`, `inf`, `pi`, `e` and `euler_gamma`. Like for any Python functionality, you can choose how to import and use them. For example, for `pi`:

```
>>> from larray import *
>>> pi
3.141592653589793
OR
>>> from larray import pi
>>> pi
3.141592653589793
OR
>>> import larray as la
>>> la.pi
3.141592653589793
```

- added `Group.equals()` method which compares group names, associated axis names and labels between two groups:

```
>>> a = Axis('a=a0..a3')
>>> a02 = a['a0:a2'] >> 'group_a'
>>> # different group name
>>> a02.equals(a['a0:a2'])
False
>>> # different axis name
>>> other_axis = a.rename('other_name')
>>> a02.equals(other_axis['a0:a2'] >> 'group_a')
False
>>> # different labels
>>> a02.equals(a['a1:a3'] >> 'group_a')
False
```

- completely rewritten the 'Load And Dump Arrays, Sessions, Axes And Groups' section of the tutorial (closes issue 645)
- saving or loading a session from a file now includes *Axis* and *Group* objects in addition to arrays (closes issue

578).

Create a session containing axes, groups and arrays

```
>>> a, b = Axis("a=a0..a2"), Axis("b=b0..b2")
>>> a01 = a['a0,a1'] >> 'a01'
>>> arr1, arr2 = ndtest((a, b)), ndtest(a)
>>> s = Session([('a', a), ('b', b), ('a01', a01), ('arr1', arr1), ('arr2',␣
↪arr2)])
```

Saving a session will save axes, groups and arrays

```
>>> s.save('session.h5')
```

Loading a session will load axes, groups and arrays

```
>>> s2 = s.load('session.h5')
>>> s2
Session(arr1, arr2, a, b, a01)
```

Note: All axes and groups of a session are stored in the same CSV file/Excel sheet/HDF group named respectively `__axes__` and `__groups__`.

- vastly improved indexing using arrays (of labels, indices or booleans). Many advanced cases did not work, including when combining several indexing arrays, or when (one of) the indexing array(s) had an axis present in the array.

  First let's create some test axes

  ```
  >>> a, b, c = ndtest((2, 3, 2)).axes
  ```

  Then create a test array.

  ```
  >>> arr = ndtest((a, b))
  >>> arr
  a\b b0 b1 b2
   a0  0  1  2
   a1  3  4  5
  ```

  If the key array has an axis not already present in arr (e.g. c), the target axis (a) is replaced by the extra axis (c). This already worked previously.

  ```
  >>> key = LArray(['a1', 'a0'], c)
  >>> key
  c   c0  c1
      a1  a0
  >>> arr[key]
  c\b  b0  b1  b2
   c0   3   4   5
   c1   0   1   2
  ```

  If the key array has the target axis, the axis stays the same, but the data is reordered (this also worked previously):

  ```
  >>> key = LArray(['b1', 'b0', 'b2'], b)
  >>> key
  ```

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```
b  b0  b1  b2
   b1  b0  b2
>>> arr[key]
a\b  b0  b1  b2
 a0   1   0   2
 a1   4   3   5
```

From here on, the examples shown did not work previously...

Now, if the key contains another axis present in the array (b) which is not the target axis (a), the target axis completely disappears (both axes are replaced by the key axis):

```
>>> key = LArray(['a0', 'a1', 'a0'], b)
>>> key
b  b0  b1  b2
   a0  a1  a0
>>> arr[key]
b  b0  b1  b2
    0   4   2
```

If the key has both the target axis (a) and another existing axis (b)

```
>>> key
a\b b0 b1 b2
 a0 a0 a1 a0
 a1 a1 a0 a1
>>> arr[key]
a\b  b0  b1  b2
 a0   0   4   2
 a1   3   1   5
```

If the key has both another existing axis (a) and an extra axis (c)

```
>>> key
a\c  c0  c1
 a0  b0  b1
 a1  b2  b0
>>> arr[key]
a\c  c0  c1
 a0   0   1
 a1   5   3
```

It also works if the key has the target axis (a), another existing axis (b) and an extra axis (c), but this is not shown for brevity.

- updated *Session.summary()* so as to display all kinds of objects and allowed to pass a function returning a string representation of an object instead of passing a pre-defined string template (closes issue 608):

```
>>> axis1 = Axis("a=a0..a2")
>>> group1 = axis1['a0,a1'] >> 'a01'
>>> arr1 = ndtest((2, 2), title='array 1', dtype=np.int64)
>>> arr2 = ndtest(4, title='array 2', dtype=np.int64)
>>> arr3 = ndtest((3, 2), title='array 3', dtype=np.int64)
>>> s = Session([('axis1', axis1), ('group1', group1), ('arr1', arr1), ('arr2',␣
↪arr2), ('arr3', arr3)])
```

Using the default template

```
>>> print(s.summary())
axis1: a ['a0' 'a1' 'a2'] (3)
group1: a['a0', 'a1'] >> a01 (2)
arr1: a, b (2 x 2) [int64]
    array 1
arr2: a (4) [int64]
    array 2
arr3: a, b (3 x 2) [int64]
    array 3
```

Using a specific template

```
>>> def print_array(key, array):
...     axes_names = ', '.join(array.axes.display_names)
...     shape = ' x '.join(str(i) for i in array.shape)
...     return "{} -> {} ({})\\n  title = {}\\n  dtype = {}".format(key, axes_
↪names, shape,
...                                                                   array.title,␣
↪array.dtype)
>>> template = {Axis:  "{key} -> {name} [{labels}] ({length})",
...             Group: "{key} -> {name}: {axis_name} {labels} ({length})",
...             LArray: print_array}
>>> print(s.summary(template))
axis1 -> a ['a0' 'a1' 'a2'] (3)
group1 -> a01: a ['a0', 'a1'] (2)
arr1 -> a, b (2 x 2)
  title = array 1
  dtype = int64
arr2 -> a (4)
  title = array 2
  dtype = int64
arr3 -> a, b (3 x 2)
  title = array 3
  dtype = int64
```

- methods `Session.equals()` and `Session.element_equals()` now also compare axes and groups in addition to arrays (closes issue 610):

```
>>> a = Axis('a=a0..a2')
>>> a01 = a['a0,a1'] >> 'a01'
>>> s1 = Session([('a', a), ('a01', a01), ('arr1', ndtest(2)), ('arr2', ndtest((2,
↪ 2)))])
>>> s2 = Session([('a', a), ('a01', a01), ('arr1', ndtest(2)), ('arr2', ndtest((2,
↪ 2)))])
```

Identical sessions

```
>>> s1.element_equals(s2)
name      a    a01   arr1   arr2
       True   True   True   True
```

Different value(s) between two arrays

```
>>> s2.arr1['a1'] = 0
>>> s1.element_equals(s2)
name      a    a01    arr1   arr2
       True   True   False   True
```

Different label(s)

```
>>> s2.arr2 = ndtest("b=b0,b1; a=a0,a1")
>>> s2.a = Axis('a=a0,a1')
>>> s1.element_equals(s2)
name       a    a01    arr1    arr2
       False   True   False   False
```

Extra/missing objects

```
>>> s2.arr3 = ndtest((3, 3))
>>> del s2.a
>>> s1.element_equals(s2)
name       a    a01    arr1    arr2    arr3
       False   True   False   False   False
```

- added arguments `wide` and `value_name` to methods `LArray.as_table()` and *`LArray.dump()`* like in *`LArray.to_excel()`* and *`LArray.to_csv()`* (closes issue 653).
- the *`from_series()`* function supports Pandas series with a MultiIndex (closes issue 465)
- the *`stack()`* function supports any array-like object instead of only LArray objects.

```
>>> stack(a0=[1, 2, 3], a1=[4, 5, 6], axis='a')
{0}*\a  a0  a1
     0   1   4
     1   2   5
     2   3   6
```

- made some operations on Excel Workbooks a bit faster by telling Excel to avoid updating the screen when the Excel instance is not visible anyway. This affects all workbooks opened via *`open_excel()`* as well as *`read_excel()`* and *`LArray.to_excel()`* when using the default `xlwings` engine.
- made the documentation link in Windows start menu version-specific (instead of always pointing to the latest release) so that users do not inadvertently use the latest release syntax when using an older version of larray (closes issue 142).
- added menu bar with undo/redo when editing single arrays (as a byproduct of issue 133).
- fixed Copy(to Excel)/Paste/Plot in the editor not working for 1D and 2D arrays (closes issue 140).
- fixed Excel add-ins not loaded when opening an Excel Workbook by calling the *`LArray.to_excel()`* method with no path or via "Copy to Excel (CTRL+E)" in the editor (closes issue 154).
- made LArray support Pandas versions >= 0.21 (closes issue 569)
- fixed current active Excel Workbook being closed when calling the *`LArray.to_excel()`* method on an array with `-1` as `filepath` argument (closes issue 473).
- fixed *`LArray.split_axes()`* when splitting a single axis and using the names argument (e.g. `arr.split_axes('bd', names=('b', 'd'))`).
- fixed splitting an anonymous axis without specifying the names argument.

```
>>> combined = ndtest('a0_b0,a0_b1,a0_b2,a1_b0,a1_b1,a1_b2')
>>> combined
{0}  a0_b0  a0_b1  a0_b2  a1_b0  a1_b1  a1_b2
         0      1      2      3      4      5
>>> combined.split_axes(0)
{0}\{1}  b0  b1  b2
```

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```
     a0    0    1    2
     a1    3    4    5
```

- fixed *LArray.combine_axes()* with `wildcard=True`.
- fixed taking a subset of an array by giving an index along a specific axis using a string (strings like `"axisname.i[pos]"`).
- fixed the editor not working with Python 2 or recent Qt4 versions.

6.1.4 Version 0.28

Released on 2018-03-15.

- changed behavior of operators *session1* == *session2* and *session1* != *session2*: returns a session of boolean arrays (closes issue 516):

```
>>> s1 = Session([('arr1', ndtest(2)), ('arr2', ndtest((2, 2)))])
>>> s2 = Session([('arr1', ndtest(2)), ('arr2', ndtest((2, 2)))])
>>> (s1 == s2).arr1
a     a0     a1
   True   True
>>> s2.arr1['a1'] = 0
>>> (s1 == s2).arr1
a     a0      a1
   True   False
>>> (s1 != s2).arr1
a      a0     a1
   False   True
```

- made it possible to run the tutorial online (as a Jupyter notebook) by clicking on the `launch|binder` badge on top of the tutorial web page (closes issue 73)
- added methods *array_equals* and *equals* to *Session* object to compare arrays from two sessions. The method *array_equals* return a boolean value for each array while the method *equals* returns a unique boolean value (True if all arrays of both sessions are equal, False otherwise):

  ```
  >>> s1 = Session([('arr1', ndtest(2)), ('arr2', ndtest((2, 2)))])
  >>> s2 = Session([('arr1', ndtest(2)), ('arr2', ndtest((2, 2)))])
  >>> s1.array_equals(s2)
  name  arr1  arr2
        True  True
  >>> s1.equals(s2)
  True
  ```

  Different value(s)

  ```
  >>> s2.arr1['a1'] = 0
  >>> s1.array_equals(s2)
  name    arr1   arr2
         False   True
  >>> s1.equals(s2)
  False
  ```

  Different label(s)

```
>>> from larray import ndrange
>>> s2.arr2 = ndrange("b=b0,b1; a=a0,a1")
>>> s1.array_equals(s2)
name   arr1   arr2
      False  False
>>> s1.equals(s2)
False
```

Extra/missing array(s)

```
>>> s2.arr3 = ndtest((3, 3))
>>> s1.array_equals(s2)
name   arr1   arr2   arr3
      False  False  False
>>> s1.equals(s2)
False
```

Closes issue 517.

- added method *equals* to *LArray* object to compare two arrays:

```
>>> arr1 = ndtest((2, 3))
>>> arr1
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> arr2 = arr1.copy()
>>> arr1.equals(arr2)
True
>>> arr2['b1'] += 1
>>> arr1.equals(arr2)
False
>>> arr3 = arr1.set_labels('a', ['x0', 'x1'])
>>> arr1.equals(arr3)
False
```

Arrays with nan values

```
>>> arr1 = ndtest((2, 3), dtype=float)
>>> arr1['a1', 'b1'] = nan
>>> arr1
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  nan  5.0
>>> arr2 = arr1.copy()
>>> # By default, an array containing nan values is never equal to␣
↪another array,
>>> # even if that other array also contains nan values at the same␣
↪positions.
>>> # The reason is that a nan value is different from *anything*,␣
↪including itself.
>>> arr1.equals(arr2)
False
>>> # set flag nan_equal to True to override this behavior
>>> arr1.equals(arr2, nan_equal=True)
True
```

This method also includes the arguments *rtol* (relative tolerance) and *atol* (absolute tolerance) allowing to test the equality between two arrays within a given relative or absolute tolerance:

```
>>> arr1 = LArray([6., 8.], "a=a0,a1")
>>> arr1
a   a0   a1
   6.0  8.0
>>> arr2 = LArray([5.999, 8.001], "a=a0,a1")
>>> arr2
a     a0     a1
   5.999  8.001
>>> arr1.equals(arr2)
False
>>> # equals returns True if abs(array1 - array2) <= (atol + rtol *␣
↪abs(array2))
>>> arr1.equals(arr2, atol=0.01)
True
>>> arr1.equals(arr2, rtol=0.01)
True
```

Closes issue 488 and issue 518.

- added *Load from Script* in the File menu of the editor allowing to load commands from an existing Python file (closes issue 96).
- added *Edit* menu allowing to undo and redo changes of array values by editing cells and removed *Apply* and *Discard* buttons. Changes are now kept when switching from an array to another instead of losing them as previously (closes issue 32).
- allowed to provide an absolute or relative tolerance value when comparing arrays through the *compare* function (closes issue 131).
- made the editor able to detect and display plot objects stored in tuple, list or arrays. For example, arrays of plot objects are returned when using *subplots=True* option in calls of *plot* method:

```
>>> a = ndtest('sex=M,F; nat=BE,FO; year=2000..2017')
>>> # display 4 plots vertically placed (one plot for each pair (sex,␣
↪nationality))
>>> a.plot(subplots=True)
>>> # display 4 plots ordered in a 2 x 2 grid
>>> a.plot(subplots=True, layout=(2, 2))
```

Closes issue 135.

- functions *local_arrays*, *global_arrays* and *arrays* returns a session excluding arrays starting by an underscore by default. To include them, set the flag *include_private* to True (closes issue 513):

```
>>> global_arr1 = ndtest((2, 2))
>>> _global_arr2 = ndtest((3, 3))
>>> def foo():
...     local_arr1 = ndtest(2)
...     _local_arr2 = ndtest(3)
...
...     # exclude arrays starting with '_' by default
...     s = arrays()
...     print(s.names)
...
...     # use flag 'include_private' to include arrays starting with '_'
...     s = arrays(include_private=True)
...     print(s.names)
```

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```
>>> foo()
['global_arr1', 'local_arr1']
['_global_arr2', '_local_arr2', 'global_arr1', 'local_arr1']
```

- implemented sessions binary operations with non sessions objects (closes issue 514 and issue 515):

  ```
  >>> s = Session(arr1=ndtest((2, 2)), arr2=ndtest((3, 3)))
  >>> s.arr1
  a\b  b0  b1
   a0   0   1
   a1   2   3
  >>> s.arr2
  a\b  b0  b1  b2
   a0   0   1   2
   a1   3   4   5
   a2   6   7   8
  ```

  Add a scalar to all arrays

  ```
  >>> # equivalent to s2 = 3 + s
  >>> s2 = s + 3
  >>> s2.arr1
  a\b  b0  b1
   a0   3   4
   a1   5   6
  >>> s2.arr2
  a\b  b0  b1  b2
   a0   3   4   5
   a1   6   7   8
   a2   9  10  11
  ```

  Apply binary operations between two sessions

  ```
  >>> sdiff = (s2 - s) / s
  >>> sdiff.arr1
  a\b   b0   b1
   a0  inf  3.0
   a1  1.5  1.0
  >>> sdiff.arr2
  a\b   b0    b1     b2
   a0  inf   3.0    1.5
   a1  1.0  0.75    0.6
   a2  0.5  0.43  0.375
  ```

- added possibility to call the method *reindex* with a group (closes issue 531):

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> b = Axis("b=b2..b0")
>>> arr.reindex('b', b['b1':])
a\b  b1  b0
 a0   1   0
 a1   3   2
```

- added possibility to call the methods *diff* and *growth_rate* with a group (closes issue 532):

```
>>> data = [[2, 4, 5, 4, 6], [4, 6, 3, 6, 9]]
>>> a = LArray(data, "sex=M,F; year=2016..2020")
>>> a
sex\year  2016  2017  2018  2019  2020
       M     2     4     5     4     6
       F     4     6     3     6     9
>>> a.diff(a.year[2017:])
sex\year  2018  2019  2020
       M     1    -1     2
       F    -3     3     3
>>> a.growth_rate(a.year[2017:])
sex\year  2018  2019  2020
       M  0.25  -0.2   0.5
       F  -0.5   1.0   0.5
```

- function *ndrange* has been deprecated in favor of *sequence* or *ndtest*. Also, an Axis or a list/tuple/collection of axes can be passed to the *ndtest* function (closes issue 534):

```
>>> ndtest("nat=BE,FO;sex=M,F")
nat\sex  M  F
     BE  0  1
     FO  2  3
```

- allowed to pass a group for argument *axis* of *stack* function (closes issue 535):

```
>>> b = Axis('b=b0..b2')
>>> stack(b0=ndtest(2), b1=ndtest(2), axis=b[:'b1'])
a\b  b0  b1
 a0   0   0
 a1   1   1
```

- renamed argument *nb_index* of *read_csv*, *read_excel*, *read_sas*, *from_lists* and *from_string* functions as *nb_axes*. The relation between *nb_index* and *nb_axes* is given by *nb_axes = nb_index + 1*:

  For a given file 'arr.csv' with content

```
a,b\c,c0,c1
a0,b0,0,1
a0,b1,2,3
a1,b0,4,5
a1,b1,6,7
```

  previous code to read this array such as :

```
>>> # deprecated
>>> arr = read_csv('arr.csv', nb_index=2)
```

  must be updated as follow :

```
>>> arr = read_csv('arr.csv', nb_axes=3)
```

  Closes issue 548.

- deprecated *nan_equal* function in favor of *element_equal* function. The *element_equal* function has the same optional arguments as the *LArray.equals* method but compares two arrays element-wise and returns an array of booleans:

```
>>> arr1 = LArray([6., np.nan, 8.], "a=a0..a2")
>>> arr1
a   a0   a1   a2
   6.0  nan  8.0
>>> arr2 = LArray([5.999, np.nan, 8.001], "a=a0..a2")
>>> arr2
a     a0   a1     a2
   5.999  nan  8.001
>>> element_equal(arr1, arr2)
a     a0     a1     a2
   False  False  False
>>> element_equal(arr1, arr2, nan_equals=True)
a     a0    a1     a2
   False  True  False
>>> element_equal(arr1, arr2, atol=0.01, nan_equals=True)
a    a0    a1    a2
   True  True  True
>>> element_equal(arr1, arr2, rtol=0.01, nan_equals=True)
a    a0    a1    a2
   True  True  True
```

Closes issue 593.

- renamed argument *transpose* by *wide* in *to_csv* method.
- added argument *wide* in *to_excel* method. When argument *wide* is set to False, the array is exported in "narrow" format, i.e. one column per axis plus one value column:

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
```

Default behavior (*wide=True*):

```
>>> arr.to_excel('my_file.xlsx')
a\b  b0  b1  b2
a0    0   1   2
a1    3   4   5
```

With *wide=False*:

```
>>> arr.to_excel('my_file.xlsx', wide=False)
 a   b  value
a0  b0      0
a0  b1      1
a0  b2      2
a1  b0      3
a1  b1      4
a1  b2      5
```

Argument *transpose* has a different purpose than *wide* and is mainly useful to allow multiple axes as header when exporting arrays with more than 2 dimensions. Closes issue 575 and issue 371.

- added argument *wide* to *read_csv* and *read_excel* functions. If False, the array to be loaded is assumed to be stored in "narrow" format:

```
>>> # assuming the array was saved using command: arr.to_excel('my_file.xlsx',␣
↪wide=False)
>>> read_excel('my_file.xlsx', wide=False)
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
```

Closes issue 574.

- added argument *name* to *to_series* method allowing to set a name to the Pandas Series returned by the method.
- added argument *value_name* to *to_csv* and *to_excel* allowing to change the default name ('value') to the column containg the values when the argument *wide* is set to False:

```
>>> arr.to_csv('my_file.csv', wide=False, value_name='data')
a,b,data
a0,b0,0
a0,b1,1
a0,b2,2
a1,b0,3
a1,b1,4
a1,b2,5
```

Closes issue 549.

- renamed argument *sheetname* of *read_excel* function as *sheet* (closes issue 587).
- Renamed *sheet_name* of *LArray.to_excel* to *sheet* since it can also be an index (closes issue 580).
- allowed to create axes with zero padded string labels (closes issue 533):

```
>>> Axis('zero_padding=01,02,03,10,11,12')
Axis(['01', '02', '03', '10', '11', '12'], 'zero_padding')
```

- added a dropdown menu containing recently used files in dialog boxes of *Save Command History To Script* and *Load from Script* from File menu.
- fixed passing a scalar group from an external axis to get a subset of an array (closes issue 178):

```
>>> arr = ndtest((3, 2))
>>> arr['a1']
b  b0  b1
    2   3
>>> alt_a = Axis("alt_a=a1..a2")
>>> arr[alt_a['a1']]
b  b0  b1
    2   3
>>> arr[alt_a.i[0]]
b  b0  b1
    2   3
```

- fixed subscript a string LGroup key (closes issue 437):

```
>>> axis = Axis("a=a0,a1")
>>> axis['a0'][0]
'a'
```

- fixed *Axis.union*, *Axis.intersection* and *Axis.difference* when passed value is a single string (closes issue 489):

```
>>> a = Axis('a=a0..a2')
>>> a.union('a1')
Axis(['a0', 'a1', 'a2'], 'a')
>>> a.union('a3')
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
>>> a.union('a1..a3')
Axis(['a0', 'a1', 'a2', 'a3'], 'a')
>>> a.intersection('a1..a3')
Axis(['a1', 'a2'], 'a')
>>> a.difference('a1..a3')
Axis(['a0'], 'a')
```

- fixed *to_excel* applied on >= 2D arrays using *transpose=True* (closes issue 579)

```
>>> arr = ndtest((2, 3))
>>> arr.to_excel('my_file.xlsx', transpose=True)
b\a  a0  a1
b0    0   3
b1    1   4
b2    2   5
```

- fixed aggregation on arrays containing zero padded string labels (closes issue 522):

```
>>> arr = ndtest('zero_padding=01,02,03,10,11,12')
>>> arr
zero_padding  01  02  03  10  11  12
               0   1   2   3   4   5
>>> arr.sum('01,02,03 >> 01_03; 10')
zero_padding  01_03  10
                  3   3
```

6.1.5 Version 0.27

Released on 2017-11-30.

- renamed *Axis.translate* to *Axis.index* (closes issue 479).
- deprecated *reverse* argument of *sort_values* and *sort_axes* methods in favor of *ascending* argument (defaults to True). Closes issue 540.
- labels are checked during array subset assignment (closes issue 269):

```
>>> arr = ndtest(4)
>>> arr
a  a0  a1  a2  a3
    0   1   2   3
>>> arr['a0,a1'] = arr['a2,a3']
ValueError: incompatible axes:
Axis(['a0', 'a1'], 'a')
vs
Axis(['a2', 'a3'], 'a')
```

previous behavior can be recovered through *drop_labels* or by changing labels via *set_labels* or *set_axes*:

```
>>> arr['a0,a1'] = arr['a2,a3'].drop_labels('a')
>>> arr['a0,a1'] = arr['a2,a3'].set_labels('a', {'a2': 'a0', 'a3': 'a1'})
```

- from_frame *parse_header* argument defaults to *False* instead of *True*.
- implemented Axis.insert and LArray.insert to add values at a given position of an axis (closes issue 54).

```
>>> arr1 = ndtest((2, 3))
>>> arr1
a\\b  b0  b1  b2
 a0    0   1   2
 a1    3   4   5
>>> arr1.insert(42, before='b1', label='b0.5')
a\\b  b0  b0.5  b1  b2
 a0    0    42   1   2
 a1    3    42   4   5
```

insert an array

```
>>> arr2 = ndtest(2)
>>> arr2
a  a0  a1
    0   1
>>> arr1.insert(arr2, after='b0', label='b0.5')
a\\b  b0  b0.5  b1  b2
 a0    0     0   1   2
 a1    3     1   4   5
```

insert an array which already has the axis

```
>>> arr3 = ndrange('a=a0,a1;b=b0.1,b0.2') + 42
>>> arr3
a\\b  b0.1  b0.2
 a0     42    43
 a1     44    45
>>> arr1.insert(arr3, before='b1')
a\\b  b0  b0.1  b0.2  b1  b2
 a0    0    42    43   1   2
 a1    3    44    45   4   5
```

- added new items in the Help menu of the editor:
  - *Report Issue...*: to report an issue on the Github project website.
  - *Users Discussion...*: redirect to the LArray Users Google Group (you need to be registered to participate).
  - *New Releases And Announces Mailing List...*: redirect to the LArray Announce mailing list.
  - *About*: give information about the editor and the versions of packages currently installed on your computer (closes issue 88).
- added *Save Command History To Script* in the File menu of the editor allowing to save executed commands in a new or existing Python file.
- added possibility to show only rows with differences when comparing arrays or sessions through the *compare* function in the editor (closes issue 102).
- added *ascending* argument to methods *indicesofsorted* and *labelsofsorted*. Values are sorted in ascending order by default. Set to False to sort values in descending order:

```
>>> arr = LArray([[1, 5], [3, 2], [0, 4]], "nat=BE,FR,IT; sex=M,F")
>>> arr
nat\sex  M  F
```

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```
     BE  1  5
     FR  3  2
     IT  0  4
>>> arr.indicesofsorted("nat", ascending=False)
nat\sex  M  F
      0  1  0
      1  0  2
      2  2  1
>>> arr.labelsofsorted("nat", ascending=False)
nat\sex   M   F
      0  FR  BE
      1  BE  IT
      2  IT  FR
```

Closes issue 490.

- allowed to sort values of an array along an axis (closes issue 225):

```
>>> a = LArray([[10, 2, 4], [3, 7, 1]], "sex=M,F; nat=EU,FO,BE")
>>> a
sex\nat  EU  FO  BE
      M  10   2   4
      F   3   7   1
>>> a.sort_values(axis='sex')
sex*\nat  EU  FO  BE
       0   3   2   1
       1  10   7   4
>>> a.sort_values(axis='nat')
sex\nat*  0  1   2
       M  2  4  10
       F  1  3   7
```

- method *LArray.sort_values* can be called without argument (closes issue 478):

```
>>> arr = LArray([0, 1, 6, 3, -1], "a=a0..a4")
>>> arr
a  a0  a1  a2  a3  a4
    0   1   6   3  -1
>>> arr.sort_values()
a  a4  a0  a1  a3  a2
   -1   0   1   3   6
```

If the array has more than one dimension, axes are combined together:

```
>>> a = LArray([[10, 2, 4], [3, 7, 1]], "sex=M,F; nat=EU,FO,BE")
>>> a
sex\nat  EU  FO  BE
      M  10   2   4
      F   3   7   1
>>> a.sort_values()
sex_nat  F_BE  M_FO  F_EU  M_BE  F_FO  M_EU
            1     2     3     4     7    10
```

- when appending/prepending/extending an array, both the original array and the added values will be converted to a data type which can hold both without loss of information. It used to convert the added values to the type of the original array. For example, given an array of integers like:

```
>>> arr = ndtest(3)
a  a0  a1  a2
    0   1   2
```

Trying to add a floating point number to that array used to result in:

```
>>> arr.append('a', 2.5, 'a3')
a  a0  a1  a2  a3
    0   1   2   2
```

Now it will result in:

```
>>> arr.append('a', 2.5, 'a3')
a   a0   a1   a2   a3
   0.0  1.0  2.0  2.5
```

- made the editor more responsive when switching to or changing the filter of large arrays (closes issue 93).
- added support for coloring numeric values for object arrays (e.g. arrays containing both strings and numbers).
- documentation links in the Help menu of the editor point to the version of the documentation corresponding to the installed version of larray (closes issue 105).
- fixed array values being editable in view() (instead of only in edit()).

6.1.6 Version 0.26.1

Released on 2017-10-25.

- Made handling Excel sheets with many blank columns/rows after the data much faster (but still slower than sheets without such blank cells).
- fixed reading from and writing to Excel sheets with 16384 columns or 1048576 rows (Excel's maximum).
- fixed LArray.split_axes using a custom separator and not using sort=True or when the split labels are ambiguous with labels from other axes (closes issue 485).
- fixed reading 1D arrays with non-string labels (closes issue 495).
- fixed read_csv(sort_columns=True) for 1D arrays (closes issue 497).

6.1.7 Version 0.26

Released on 2017-10-13.

- renamed special variable *x* to *X* to let users define an *x* variable in their code without breaking all subsequent code using that special variable (closes issue 167).
- renamed Axis.startswith, endswith and matches to startingwith, endingwith and matching to avoid a possible confusion with str.startswith and endswith which return booleans (closes issue 432).
- renamed *na* argument of *read_csv*, *read_excel*, *read_hdf* and *read_sas* functions to *fill_value* to avoid confusion as to what the argument does and to be consistent with *reindex* and *align* (closes issue 394).
- renamed *split_axis* to *split_axes* to reflect the fact that it can now split several axes at once (see below).
- renamed *sort_axis* to *sort_axes* to reflect the fact that it can sort multiple axes at once (and does so by default).
- renamed several methods with more explicit names (closes issue 50):

  - *argmax*, *argmin*, *argsort* to *labelofmax*, *labelofmin*, *labelsofsorted*
  - *posargmax*, *posargmin*, *posargsort* to *indexofmax*, *indexofmin*, *indicesofsorted*

- renamed PGroup to IGroup to be consistent with other methods, especially the .i methods on axes and arrays (I is for Index – P was for Position).
- getting a subset using a boolean selection returns an array with labels combined with underscore by defaults (for consistency with *split_axes* and *combine_axes*). Closes issue 376:

```
>>> arr = ndtest((2, 2))
>>> arr
a\b  b0  b1
 a0   0   1
 a1   2   3
>>> arr[arr < 3]
a_b  a0_b0  a0_b1  a1_b0
         0      1      2
```

- added global_arrays() and arrays() functions to complement the local_arrays() function. They return a Session containing respectively all arrays defined in global variables and all available arrays (whether they are defined in local or global variables).

  When used outside of a function, these three functions should have the same results, but inside a function local_arrays() will return only arrays local to the function, global_arrays() will return only arrays defined globally and arrays() will return arrays defined either locally or globally. Closes issue 416.
- a * symbol is appended to the window title when unsaved changes are detected in the viewer (closes issue 21).
- implemented Axis.containing to create a Group with all labels of an axis containing some substring (closes issue 402).

```
>>> people = Axis(['Bruce Wayne', 'Bruce Willis', 'Arthur Dent'], 'people')
>>> people.containing('Will')
people['Bruce Willis']
```

- implemented Group.containing, startingwith, endingwith and matching to create a group with all labels of a group matching some criterion (closes issue 108).

```
>>> group = people.startingwith('Bru')
>>> group
people['Bruce Wayne', 'Bruce Willis']
>>> group.containing('Will')
people['Bruce Willis']
```

- implemented nan_equal() function to create an array of booleans telling whether each cell of the first array is equal to the corresponding cell in the other array, even in the presence of NaN.

```
>>> arr1 = ndtest(3, dtype=float)
>>> arr1['a1'] = nan
>>> arr1
a   a0   a1   a2
   0.0  nan  2.0
>>> arr2 = arr1.copy()
>>> arr1 == arr2
a    a0     a1    a2
   True  False  True
>>> nan_equal(arr1, arr2)
a    a0    a1    a2
   True  True  True
```

- implemented from_frame() to convert a Pandas DataFrame to an array:

```
>>> df = ndtest((2, 2, 2)).to_frame()
>>> df
c      c0  c1
a  b
a0 b0   0   1
   b1   2   3
a1 b0   4   5
   b1   6   7
>>> from_frame(df)
 a  b\\c  c0  c1
a0   b0   0   1
a0   b1   2   3
a1   b0   4   5
a1   b1   6   7
```

- implemented Axis.split to split an axis into several.

```
>>> a_b = Axis('a_b=a0_b0,a0_b1,a0_b2,a1_b0,a1_b1,a1_b2')
>>> a_b.split()
[Axis(['a0', 'a1'], 'a'), Axis(['b0', 'b1', 'b2'], 'b')]
```

- added the possibility to load the example dataset used in the tutorial via the menu `File > Load Example` in the viewer
- view() and edit() without argument now display global arrays in addition to local ones (closes issue 54).
- using the mouse scrollwheel on filter combo boxes will switch to the previous/next label.
- implemented a combobox to choose which color gradient to use and provide a few gradients.
- inverted background colors in the viewer (red for low values and blue for high values). Closes issue 18.
- allowed to pass an array of labels as *new_axis* argument to *reindex* method (closes issue 384):

```
>>> arr = ndrange('a=v0..v1;b=v0..v2')
>>> arr
a\b  v0  v1  v2
 v0   0   1   2
 v1   3   4   5
>>> arr.reindex('a', arr.b.labels)
a\b   v0   v1   v2
 v0    0    1    2
 v1    3    4    5
 v2  nan  nan  nan
```

- allowed to call the *reindex* method using a differently named axis for labels (closes issue 386):

```
>>> arr = ndrange('a=v0..v1;b=v0..v2')
>>> arr
a\b  v0  v1  v2
 v0   0   1   2
 v1   3   4   5
>>> arr.reindex('a', arr.b)
a\b   v0   v1   v2
 v0    0    1    2
 v1    3    4    5
 v2  nan  nan  nan
```

- arguments *fill_value*, *sort_rows* and *sort_columns* of *read_excel* function are also supported by the default *xlwings* engine (closes issue 393).
- allowed to pass a label or group as *sheet_name* argument of the method *to_excel* or to a Workbook (*open_excel*). Same for *key* argument of the method *to_hdf*. Closes issue 328.

```
>>> arr = ndtest((4, 4, 4))
```

```
>>> # iterate over labels of a given axis
>>> with open_excel('my_file.xlsx') as wb:
>>>     for label in arr.a:
...         wb[label] = arr[label].dump()
...     wb.save()
>>> for label in arr.a:
...     arr[label].to_hdf('my_file.h5', label)
```

```
>>> # create and use a group
>>> even = arr.a['a0,a2'] >> 'even'
>>> arr[even].to_excel('my_file.xlsx', even)
>>> arr[even].to_hdf('my_file.h5', even)
```

```
>>> # special characters : \ / ? * [ or ] in labels or groups are replaced by an _
↪ when exporting to excel
>>> # sheet names cannot exceed 31 characters
>>> g = arr.a['a1,a3,a4'] >> '?name:with*special\/[char]'
>>> arr[g].to_excel('my_file.xlsx', g)
>>> print(open_excel('my_file.xlsx').sheet_names())
['_name_with_special___char_']
>>> # special characters \ or / in labels or groups are replaced by an _ when␣
↪exporting to HDF file
```

- allowed to pass a Group to *read_excel*/*read_hdf* as *sheetname*/*key* argument (closes issue 439).

```
>>> a, b, c = arr.a, arr.b, arr.c
```

```
>>> # For Excel
>>> new_from_excel = zeros((a, b, c), dtype=int)
>>> for label in a:
...     new_from_excel[label] = read_excel('my_file.xlsx', label)
>>> # But, to avoid loading the file in Excel repeatedly (which is very␣
↪inefficient),
>>> # this particular example should rather be written like this:
>>> new_from_excel = zeros((a, b, c), dtype=int)
>>> with open_excel('my_file.xlsx') as wb:
...     for label in a:
...         new_from_excel[label] = wb[label].load()
```

```
>>> # For HDF
>>> new_from_hdf = zeros((a, b, c), dtype=int)
>>> for label in a:
...     new_from_hdf[label] = read_hdf('my_file.h5', label)
```

- allowed setting the name of a Group using another Group or Axis (closes issue 341):

```
>>> arr = ndrange('axis=a,a0..a3,b,b0..b3,c,c0..c3')
>>> arr
```

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```
axis   a  a0  a1  a2  a3  b  b0  b1  b2  b3   c  c0  c1  c2  c3
       0   1   2   3   4  5   6   7   8   9  10  11  12  13  14
>>> # matches('^.$') will select labels with only one character: 'a', 'b' and 'c'
>>> groups = tuple(arr.axis.startswith(code) >> code for code in arr.axis.matches(
↪'^.$'))
>>> groups
(axis['a', 'a0', 'a1', 'a2', 'a3'] >> 'a',
 axis['b', 'b0', 'b1', 'b2', 'b3'] >> 'b',
 axis['c', 'c0', 'c1', 'c2', 'c3'] >> 'c')
>>> arr.sum(groups)
axis   a   b   c
      10  35  60
```

- allowed to test if an array contains a label using the *in* operator (closes issue 343):

```
>>> arr = ndrange('age=0..99;sex=M,F')
>>> 'M' in arr
True
>>> 'Male' in arr
False
>>> # this can be useful for example in an 'if' statement
>>> if 102 not in arr:
...     # with 'reindex', we extend 'age' axis to 102
...     arr = arr.reindex('age', Axis('age=0..102'), fill_value=0)
>>> arr.info
103 x 2
 age [103]: 0 1 2 ... 100 101 102
 sex [2]: 'M' 'F'
```

- allowed to create a group on an axis using labels of another axis (closes issue 362):

```
>>> year = Axis('year=2000..2017')
>>> even_year = Axis(range(2000, 2017, 2), 'even_year')
>>> group_even_year = year[even_year]
>>> group_even_year
year[2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014, 2016]
```

- *split_axes* (formerly *split_axis*) now allows to split several axes at once (closes issue 366):

```
>>> combined = ndrange('a_b = a0_b0..a1_b1; c_d = c0_d0..c1_d1')
>>> combined
a_b\c_d  c0_d0  c0_d1  c1_d0  c1_d1
  a0_b0      0      1      2      3
  a0_b1      4      5      6      7
  a1_b0      8      9     10     11
  a1_b1     12     13     14     15
>>> combined.split_axes(['a_b', 'c_d'])
 a   b  c\d  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
>>> combined.split_axes({'a_b': ('A', 'B'), 'c_d': ('C', 'D')})
```

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```
 A   B  C\D  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
```

- argument *axes* of *split_axes* has become optional: defaults to all axes whose name contains the specified delimiter (closes issue 365):

```
>>> combined = ndrange('a_b = a0_b0..a1_b1; c_d = c0_d0..c1_d1')
>>> combined
a_b\c_d  c0_d0  c0_d1  c1_d0  c1_d1
  a0_b0      0      1      2      3
  a0_b1      4      5      6      7
  a1_b0      8      9     10     11
  a1_b1     12     13     14     15
>>> combined.split_axes()
 a   b  c\d  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
```

- allowed to perform several axes combinations at once with the *combine_axes()* method (closes issue 382):

```
>>> arr = ndtest((2, 2, 2, 2))
>>> arr
 a   b  c\d  d0  d1
a0  b0   c0   0   1
a0  b0   c1   2   3
a0  b1   c0   4   5
a0  b1   c1   6   7
a1  b0   c0   8   9
a1  b0   c1  10  11
a1  b1   c0  12  13
a1  b1   c1  14  15
>>> arr.combine_axes([('a', 'c'), ('b', 'd')])
a_c\b_d  b0_d0  b0_d1  b1_d0  b1_d1
  a0_c0      0      1      4      5
  a0_c1      2      3      6      7
  a1_c0      8      9     12     13
  a1_c1     10     11     14     15
>>> # set output axes names by passing a dictionary
>>> arr.combine_axes({('a', 'c'): 'ac', ('b', 'd'): 'bd'})
ac\bd  b0_d0  b0_d1  b1_d0  b1_d1
a0_c0      0      1      4      5
a0_c1      2      3      6      7
a1_c0      8      9     12     13
a1_c1     10     11     14     15
```

- allowed to use keyword arguments in *set_labels* (closes issue 383):

```
>>> a = ndrange('nat=BE,FO;sex=M,F')
>>> a
nat\sex  M  F
     BE  0  1
     FO  2  3
>>> a.set_labels(sex='Men,Women', nat='Belgian,Foreigner')
  nat\sex  Men  Women
  Belgian    0      1
Foreigner    2      3
```

- allowed passing an axis to *set_labels* as 'labels' argument (closes issue 408).
- added data type (dtype) to array.info (closes issue 454):

```
>>> arr = ndtest((2, 2), dtype=float)
>>> arr
a\b   b0   b1
 a0  0.0  1.0
 a1  2.0  3.0
>>> arr.info
2 x 2
 a [2]: 'a0' 'a1'
 b [2]: 'b0' 'b1'
dtype: float64
```

- To create a 1D array using from_string() and the default separator " ", a tabulation character `\t` (instead of – previously) must be added in front of the data line:

```
>>> from_string('''sex  M  F
...                \t   0  1''')
sex  M  F
     0  1
```

- viewer window title also includes the dtype of the current displayed array (closes issue 85)
- viewer window title uses only the file name instead of the entire file path as it made titles too long in some cases.
- when editing .csv files, the viewer window title will be "directoryfname.csv - axes_info" instead of having the file name repeated as before ("dirfname.csv - fname: axes_info").
- the viewer will not update digits/scientific notation nor colors when the filter changes, so that numbers are more easily comparable when quickly changing the filter, especially using the scrollwheel on filter boxes.
- NaN values display as grey in the viewer so that they stand out more.
- compare() will color values depending on relative difference instead of absolute difference as this is usually more useful.
- compare(sessions) uses nan_equal to compare arrays so that identical arrays are not marked different when they contain NaN values.
- changed compare() "stacked axis" names: arrays -> array and sessions -> session because that reads a bit more naturally.
- fixed array creation with axis(es) given as string containing only one label (axis name and label were inverted).
- fixed reading an array from a CSV or Excel file when the columns axis is not explicitly named (via `\`). For example, let's say we want to read a CSV file 'pop.csv' with the following content (indented for clarity)

```
sex, 2015, 2016
  F,   11,   13
  M,   12,   10
```

The result of function *read_csv* is:

```
>>> pop = read_csv('pop.csv')
>>> pop
sex\{1}  2015  2016
      F    11    13
      M    12    10
```

Closes issue 372.

- fixed converting a 1xN Pandas DataFrame to an array using *aslarray* (closes issue 427):

```
>>> df = pd.DataFrame([[1, 2, 3]], index=['a0'], columns=['b0', 'b1', 'b2'])
>>> df
    b0  b1  b2
a0   1   2   3
>>> aslarray(df)
{0}\{1}  b0  b1  b2
     a0   1   2   3
```

```
>>> # setting name to index and columns
>>> df.index.name = 'a'
>>> df.columns.name = 'b'
>>> df
b   b0  b1  b2
a
a0   1   2   3
>>> aslarray(df)
a\b  b0  b1  b2
 a0   1   2   3
```

- fixed original file being deleted when trying to overwrite a file via *Session.save* or *open_excel* failed (closes issue 441)
- fixed loading arrays from Excel sheets containing blank cells below or right of the array to read (closes issue 443)
- fixed unary and binary operations between sessions failing entirely when the operation failed/was invalid on any array. Now the result will be nan for that array but the operation will carry on for other arrays.
- fixed stacking sessions failing entirely when the stacking failed on any array. Now the result will be nan for that array but the operation will carry on for other arrays.
- fixed stacking arrays with anonymous axes.
- fixed applying *split_axes* on an array with labels of type 'Object' (could happen when an array is read from a file).
- fixed background color in the viewer when using filters in the *compare()* dialog (closes issue 66)
- fixed autoresize of columns by double clicking between column headers (closes issue 43)
- fixed representing a 0D array (scalar) in the viewer (closes issue 71)
- fixed viewer not displaying an error message when saving or loading a file failed (closes issue 75)

- fixed array.split_axis when the combined axis does not contain all the combination of labels resulting from the split (closes issue 369).
- fixed array.split_axis when combined labels are not sorted by the first part then second part (closes issue 364).
- fixed opening .csv files in the editor will create variables named using only the filename without extension (instead of being named using the full path of the file – making it almost useless). Closes issue 90.
- fixed deleting a variable (using the del key in the list) not marking the session/file as being modified.
- fixed the link to the tutorial (Help->Online Tutorial) (closes issue 92).
- fixed inplace modifications of arrays in the console (via array[xxx] = value) not updating the view (closes issue 94).
- fixed background color in compare() being wrong after changing axes order by drag-and-dropping them (closes issue 89).
- fixed the whole array/compare being the same color in the presence of -inf or +inf in the array.

6.1.8 Version 0.25.2

Released on 2017-09-06.

- Excel Workbooks opened with open_excel(visible=False) will use the global Excel instance by default and those using visible=True will use a new Excel instance by default (closes issue 405).
- fixed view() which did not show any array (closes issue 57).
- fixed exceptions in the viewer crashing it when a Qt app was created (e.g. from a plot) before the viewer was started (closes issue 58).
- fixed compare() arrays names not being determined correctly (closes issue 61).
- fixed filters and title not being updated when displaying array created via the console (closes issue 55).
- fixed array grid not being updated when selecting a variable when no variable was selected (closes issue 56).
- fixed copying or plotting multiple rows in the editor when they were selected via drag and drop on headers (closes issue 59).
- fixed digits not being automatically updated when changing filters.

6.1.9 Version 0.25.1

Released on 2017-09-04.

- Deprecated methods display a warning message when they are still used (replaced DeprecationWarning by FutureWarning). Closes issue 310.
- updated documentation of method *with_total* (closes issue 89).
- trying to set values of a subset by passing an array with incompatible axes displays a better error message (closes issue 268).
- fixed error raised in viewer when switching between arrays when a filter was set.
- fixed displaying empty array when starting the viewer or a new session in it.
- fixed Excel instance created via to_excel() and open_excel() without any filename being closed at the end of the Python program (closes issue 390).
- fixed the *view()*, *edit()* and *compare()* functions not being available in the viewer console.

- fixed row and column resizing by double clicking on the edge of an header cell.
- fixed *New* and *Open* in the menu *File* of the viewer when IPython console is not available.
- fixed getting a subset of an array by mixing boolean filters and other filters (closes issue 246):

```
>>> arr = ndrange('a=a0..a2;b=0..3')
>>> arr
a\b  0  1   2   3
 a0  0  1   2   3
 a1  4  5   6   7
 a2  8  9  10  11
>>> arr['a0,a2', x.b < 2]
a\b  0  1
 a0  0  1
 a2  8  9
```

  Warning: when mixed with other filters, boolean filters are limited to one dimension.

- fixed setting an array values using *array.points[key] = value* when value is an LArray (closes issue 368).
- fixed using syntax 'int..int' in a selection (closes issue 350):

```
>>> arr = ndrange('a=2017..2012')
>>> arr
a  2017  2016  2015  2014  2013  2012
      0     1     2     3     4     5
>>> arr['2012..2015']
a  2012  2013  2014  2015
      5     4     3     2
```

- fixed mixing '..' sequences and spaces in an indexing string (closes issue 389):

```
>>> arr = ndtest(7)
>>> arr
a  a0  a1  a2  a3  a4  a5  a6
    0   1   2   3   4   5   6
>>> arr['a0, a2, a4..a6']
a  a0  a2  a4  a5  a6
    0   2   4   5   6
```

- fixed indexing/aggregating using groups with renaming (using >>) when the axis has mixed type labels (object dtype).

6.1.10 Version 0.25

Released on 2017-08-22.

- viewer functions (*view*, *edit* and *compare*) have been moved to the separate *larray-editor* package, which needs to be installed separately, unless you are using *larrayenv*. Closes issue 332.
- installing larray-editor (or larrayenv) from conda environment creates a new menu 'LArray' in the Windows start menu. It contains a link to open the documentation, a shortcut to launch the user interface in edition mode and a shortcut to update larrayenv. Closes issue 281.
- added possibility to transpose an array in the viewer by dragging and dropping axes' names in the filter bar.
- implemented array.align(other_array) which makes two arrays compatible with each other (by making all common axes compatible). This is done by adding, removing or reordering labels for each common axis according to the join method used:

- outer: will use a label if it is in either arrays axis (ordered like the first array). This is the default as it results in no information loss.
- inner: will use a label if it is in both arrays axis (ordered like the first array)
- left: will use the first array axis labels
- right: will use the other array axis labels

The fill value for missing labels defaults to nan.

```
>>> arr1 = ndtest((2, 3))
>>> arr1
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> arr2 = -ndtest((3, 2))
>>> # reorder array to make the test more interesting
>>> arr2 = arr2[['b1', 'b0']]
>>> arr2
a\\b  b1  b0
 a0  -1   0
 a1  -3  -2
 a2  -5  -4
```

Align arr1 and arr2

```
>>> aligned1, aligned2 = arr1.align(arr2)
>>> aligned1
a\b   b0   b1   b2
 a0  0.0  1.0  2.0
 a1  3.0  4.0  5.0
 a2  nan  nan  nan
>>> aligned2
a\b    b0    b1   b2
 a0   0.0  -1.0  nan
 a1  -2.0  -3.0  nan
 a2  -4.0  -5.0  nan
```

After aligning all common axes, one can then do operations between the two arrays

```
>>> aligned1 + aligned2
a\b   b0   b1   b2
 a0  0.0  0.0  nan
 a1  1.0  1.0  nan
 a2  nan  nan  nan
```

The fill value for missing labels defaults to nan but can be changed to any compatible value.

```
>>> aligned1, aligned2 = arr1.align(arr2, fill_value=0)
>>> aligned1
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
 a2   0   0   0
>>> aligned2
a\b  b0  b1  b2
 a0   0  -1   0
 a1  -2  -3   0
```

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```
 a2  -4  -5   0
>>> aligned1 + aligned2
a\b  b0  b1  b2
 a0   0   0   2
 a1   1   1   5
 a2  -4  -5   0
```

- implemented Session.transpose(axes) to reorder axes of all arrays within a session, ignoring missing axes for each array. For example, let us first create a test session and a small helper function to display sessions as a short summary.

```
>>> arr1 = ndtest((2, 2, 2))
>>> arr2 = ndtest((2, 2))
>>> sess = Session([('arr1', arr1), ('arr2', arr2)])
>>> def print_summary(s):
...     print(s.summary("{name} -> {axes_names}"))
>>> print_summary(sess)
arr1 -> a, b, c
arr2 -> a, b
```

Put the 'b' axis in front of all arrays

```
>>> print_summary(sess.transpose('b'))
arr1 -> b, a, c
arr2 -> b, a
```

Axes missing on an array are ignored ('c' for arr2 in this case)

```
>>> print_summary(sess.transpose('c', 'b'))
arr1 -> c, b, a
arr2 -> b, a
```

Use ... to move axes to the end

```
>>> print_summary(sess.transpose(..., 'a'))
arr1 -> b, c, a
arr2 -> b, a
```

- implemented unary operations on Session, which means one can negate all arrays in a Session or take the absolute value of all arrays in a Session without writing an explicit loop for that.

```
>>> arr1 = ndtest(2)
>>> arr1
a  a0  a1
    0   1
>>> arr2 = ndtest(4) - 1
>>> arr2
a  a0  a1  a2  a3
   -1   0   1   2
>>> sess1 = Session([('arr1', arr1), ('arr2', arr2)])
>>> sess2 = -sess1
>>> sess2.arr1
a  a0  a1
    0  -1
>>> sess2.arr2
a  a0  a1  a2  a3
```

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```
    1   0  -1  -2
>>> sess3 = abs(sess1)
>>> sess3.arr2
a  a0  a1  a2  a3
    1   0   1   2
```

- implemented stacking sessions using stack().

  Let us first create two test sessions. For example suppose we have a session storing the results of a baseline simulation:

```
>>> arr1 = ndtest(2)
>>> arr1
a  a0  a1
    0   1
>>> arr2 = ndtest(3)
>>> arr2
a  a0  a1  a2
    0   1   2
>>> baseline = Session([('arr1', arr1), ('arr2', arr2)])
```

  and another session with a variant

```
>>> arr1variant = arr1 * 2
>>> arr1variant
a  a0  a1
    0   2
>>> arr2variant = 2 - arr2 / 2
>>> arr2variant
a    a0   a1   a2
   2.0  1.5  1.0
>>> variant = Session([('arr1', arr1variant), ('arr2', arr2variant)])
```

  then we stack them together

```
>>> stacked = stack([('baseline', baseline), ('variant', variant)], 'sessions')
>>> stacked
Session(arr1, arr2)
>>> stacked.arr1
a\sessions  baseline  variant
        a0         0        0
        a1         1        2
>>> stacked.arr2
a\sessions  baseline  variant
        a0       0.0      2.0
        a1       1.0      1.5
        a2       2.0      1.0
```

  Combined with the fact that we can compute some very simple expressions on sessions, this can be extremely useful to quickly compare all arrays of several sessions (e.g. simulation variants):

```
>>> diff = variant - baseline
>>> # compute the absolute difference and relative difference for each array of
↪the sessions
>>> stacked = stack([('baseline', baseline),
                     ('variant', variant),
                     ('diff', diff),
```

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```
                        ('abs diff', abs(diff)),
                        ('rel diff', diff / baseline)], 'sessions')
>>> stacked
Session(arr1, arr2)
>>> stacked.arr2
a\sessions  baseline  variant  diff  abs diff  rel diff
        a0       0.0      2.0   2.0       2.0       inf
        a1       1.0      1.5   0.5       0.5       0.5
        a2       2.0      1.0  -1.0       1.0      -0.5
```

- implemented Axis.align(other_axis) and AxisCollection.align(other_collection) which makes two axes / axis collections compatible with each other, see LArray.align above.
- implemented Session.apply(function) to apply a function to all elements (arrays) of a Session and return a new Session.

  Let us first create a test session

```
>>> arr1 = ndtest(2)
>>> arr1
a  a0  a1
    0   1
>>> arr2 = ndtest(3)
>>> arr2
a  a0  a1  a2
    0   1   2
>>> sess1 = Session([('arr1', arr1), ('arr2', arr2)])
>>> sess1
Session(arr1, arr2)
```

  Then define the function we want to apply to all arrays of our session

```
>>> def increment(element):
...     return element + 1
```

  Apply it

```
>>> sess2 = sess1.apply(increment)
>>> sess2.arr1
a  a0  a1
    1   2
>>> sess2.arr2
a  a0  a1  a2
    1   2   3
```

- implemented setting the value of multiple points using array.points[labels] = value

```
>>> arr = ndtest((3, 4))
>>> arr
a\b  b0  b1  b2  b3
 a0   0   1   2   3
 a1   4   5   6   7
 a2   8   9  10  11
```

  Now, suppose you want to retrieve several specific combinations of labels, for example (a0, b1), (a0, b3), (a1, b0) and (a2, b2). You could write a loop like this:

```
>>> values = []
>>> for a, b in [('a0', 'b1'), ('a0', 'b3'), ('a1', 'b0'), ('a2', 'b2')]:
...     values.append(arr[a, b])
>>> values
[1, 3, 4, 10]
```

but you could also (this already worked in previous versions) use array.points like:

```
>>> arr.points[['a0', 'a0', 'a1', 'a2'], ['b1', 'b3', 'b0', 'b2']]
a,b  a0,b1  a0,b3  a1,b0  a2,b2
         1      3      4     10
```

which has the advantages of being both much faster and keep more information. Now suppose you want to *set* the value of those points, you could write:

```
>>> for a, b in [('a0', 'b1'), ('a0', 'b3'), ('a1', 'b0'), ('a2', 'b2')]:
...     arr[a, b] = 42
>>> arr
a\b  b0  b1  b2  b3
 a0   0  42   2  42
 a1  42   5   6   7
 a2   8   9  42  11
```

but now you can also use the faster alternative:

```
>>> arr.points[['a0', 'a0', 'a1', 'a2'], ['b1', 'b3', 'b0', 'b2']] = 42
```

- added icon to display in Windows start menu and editor windows.
- viewer keeps labels visible even when scrolling (label rows and columns are now frozen).
- added 'Getting Started' section in documentation.
- implemented axes argument to ipfp to specify on which axes the fitting procedure should be applied (closes issue 185). For example, let us assume you have a 3D array, such as:

```
>>> initial = ndrange('a=a0..a9;b=b0..b9;year=2000..2016')
```

and you want to apply a 2D fitting procedure for each value of the year axis. Previously, you had to loop on that year axis explicitly and call ipfp within the loop, like:

```
>>> result = zeros(initial.axes)
>>> for year in initial.year:
...     current = initial[year]
...     # assume you have some targets for each year
...     current_targets = [current.sum(x.a) + 1, current.sum(x.b) + 1]
...     result[year] = ipfp(current_targets, current)
```

Now you can apply the procedure on all years at once, by telling you want to do the fitting procedure on the other axes. This is a bit shorter to type, but this is also *much* faster.

```
>>> all_targets = [initial.sum(x.a) + 1, initial.sum(x.b) + 1]
>>> result = ipfp(all_targets, initial, axes=(x.a, x.b))
```

- made ipfp 10 to 20% faster (even without using the axes argument).
- implemented Session.to_globals(inplace=True) which will update the content of existing arrays instead of creating new variables and overwriting them. This ensures the arrays have the same axes in the session than the existing variables.

- added the ability to provide a pattern when loading several .csv files as a session. Among others, patterns can use * to match any number of characters and ? to match any single character.

```
>>> s = Session()
>>> # load all .csv files starting with "output" in the data directory
>>> s.load('data/output*.csv')
```

- stack can be used with keyword arguments when labels are "simple strings" (i.e. no integers, no punctuation, no string starting with integers, etc.). This is an attractive alternative but as it only works in the usual case and not in all cases, it is not recommended to use it except in the interactive console.

```
>>> arr1 = ones('nat=BE,FO')
>>> arr1
nat   BE   FO
     1.0  1.0
>>> arr2 = zeros('nat=BE,FO')
>>> arr2
nat   BE   FO
     0.0  0.0
>>> stack(M=arr1, F=arr2, axis='sex=M,F')
nat\\sex    M    F
     BE  1.0  0.0
     FO  1.0  0.0
```

Without passing an explicit order for labels like above (or an axis object), it should only be used on Python 3.6 or later because keyword arguments are NOT ordered on earlier Python versions.

```
>>> # use this only on Python 3.6 and later
>>> stack(M=arr1, F=arr2, axis='sex')
nat\\sex    M    F
     BE  1.0  0.0
     FO  1.0  0.0
```

- binary operations between session now ignore type errors. For example, if you are comparing two sessions with many arrays by computing the difference between them but a few arrays contain strings, the whole operation will not fail, the concerned arrays will be assigned a nan instead.
- added optional argument *ignore_exceptions* to Session.load to ignore exceptions during load. This is mostly useful when trying to load many .csv files in a Session and some of them have an invalid format but you want to load the others.
- fixed disambiguating an ambiguous key by adding the axis within the string, for example arr['axis_name[ambiguouslabel]'] (closes issue 331).
- fixed converting a string group to integer or float using int() and float() (when that makes sense).

```
>>> a = Axis('a=10,20,30,total')
>>> a
Axis(['10', '20', '30', 'total'], 'a')
>>> str(a.i[0])
'10'
>>> int(a.i[0])
10
>>> float(a.i[0])
10.0
```

6.1.11 Version 0.24.1

Released on 2017-06-14.

- updated the tutorial to use version 0.24 syntax.

6.1.12 Version 0.24

Released on 2017-06-14.

- implemented Session.to_globals which creates global variables from variables stored in the session (closes issue 276). Note that this should usually only be used in an interactive console and not in a script. Code editors are confused by this kind of manipulation and will likely consider as invalid the code using variables created in this way. Additionally, when using this method auto-completion, "show definition", "go to declaration" and other similar code editor features will probably not work for the variables created in this way and any variable derived from them.

```
>>> s = Session(arr1=ndtest(3), arr2=ndtest((2, 2)))
>>> s.to_globals()
>>> arr1
a  a0  a1  a2
    0   1   2
>>> arr2
a\b  b0  b1
 a0   0   1
 a1   2   3
```

- added new boolean argument 'overwrite' to Session.save, Session.to_hdf, Session.to_excel and Session.to_pickle methods (closes issue 293). If overwrite=True and the target file already existed, it is deleted and replaced by a new one. This is the new default behavior. If overwrite=False, an existing file is updated (like it was in previous larray versions):

```
>>> arr1, arr2, arr3 = ndtest((2, 2)), ndtest(4), ndtest((3, 2))
>>> s = Session([('arr1', arr1), ('arr2', arr2), ('arr3', arr3)])
```

```
>>> # save arr1, arr2 and arr3 in file output.h5
>>> s.save('output.h5')
```

```
>>> # replace arr1 and create arr4 + put them in an second session
>>> arr1, arr4 = ndtest((3, 3)), ndtest((2, 3))
>>> s2 = Session([('arr1', arr1), ('arr4', arr4)])
```

```
>>> # replace arr1 and add arr4 in file output.h5
>>> s2.save('output.h5', overwrite=False)
```

```
>>> # erase content of 'output.h5' and save only arrays contained in the second␣
↪session
>>> s2.save('output.h5')
```

- renamed create_sequential() to sequence() (closes issue 212).
- improved auto-completion in ipython interactive consoles (e.g. the viewer console) for Axis, AxisCollection, Group and Workbook objects. These objects can now complete keys within [].

```
>>> gender = Axis('gender=Male,Female')
>>> gender
Axis(['Male', 'Female'], 'gender')
gender['Female
>>> gender['Fe<tab>  # will be completed to `gender['Female`
```

```
>>> arr = ndrange(gender)
>>> arr.axes['gen<tab>  # will be completed to `arr.axes['gender`
```

```
>>> wb = open_excel()
>>> wb['Sh<tab>  # will be completed to `wb['Sheet1`
```

- added documentation for Session methods (closes issue 277).
- allowed to provide explict names for arrays or sessions in compare(). Closes issue 307.
- fixed title argument of *ndtest* creation function: title was not passed to the returned array.
- fixed create_sequential when arguments initial and inc are array and scalar respectively (closes issue 288).
- fixed auto-completion of attributes of LArray and Group objects (closes issue 302).
- fixed name of arrays/sessions in compare() not being inferred correctly (closes issue 306).
- fixed indexing Excel sheets by position to always yield the requested shape even when bounds are outside the range of used cells. Closes issue 273.
- fixed the array() method on excel.Sheet returning float labels when int labels are expected.
- fixed getting float data instead of int when converting an Excel Sheet or Range to an larray or numpy array.
- fixed some warning messages to point to the correct line in user code.
- fixed crash of Session.save method when it contained 0D arrays. They are now skipped when saving a session (closes issue 291).
- fixed Session.save and Session.to_excel failing to create new Excel files (it only worked if the file already existed). Closes issue 313.
- fixed Session.load(file, engine='pandas_excel') : axes were considered as anonymous.

6.1.13 Version 0.23

Released on 2017-05-30.

- changed display of arrays (closes issue 243):

```
>>> ndtest((2, 3))
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
```

instead of

```
>>> ndtest((2, 3))
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  2
 a1 |  3 |  4 |  5
```

- .. can now be used within keys (between []). Previously it could only be used to define new axes. As a reminder, it generates increasing values between the two bounds. It is slightly different from : which takes everything between the two bounds **in the axis order**.

```
>>> arr = ndrange('a=a1,a0,a2,a3')
>>> arr
a  a1  a0  a2  a3
    0   1   2   3
>>> arr['a1..a3']
a  a1  a2  a3
    0   2   3
```

  this is different from *:* which takes everything in between the two bounds :

```
>>> arr['a1:a3']
a  a1  a0  a2  a3
    0   1   2   3
```

- in both axes definitions and keys (within []) .. can now be mixed with , and other .. :

```
>>> arr = ndrange('code=A,C..E,G,X..Z')
>>> arr
code  A  C  D  E  G  X  Y  Z
      0  1  2  3  4  5  6  7
>>> arr['A,Z..X,G']
code  A  Z  Y  X  G
      0  7  6  5  4
```

- within .. extra zeros are only padded to numbers if zeros are present in the pattern.

```
>>> ndrange('code=A1..A12')
code  A1  A2  A3  A4  A5  A6  A7  A8  A9  A10  A11  A12
       0   1   2   3   4   5   6   7   8    9   10   11
```

```
>>> ndrange('code=A01..A12')
code  A01  A02  A03  A04  A05  A06  A07  A08  A09  A10  A11  A12
        0    1    2    3    4    5    6    7    8    9   10   11
```

  in previous larray versions, the two above definitions returned the second array.

- set *sep* argument of from_string function to ' ' by default (closes issue 271). For 1D array, a "-" must be added in front of the data line.

```
>>> from_string('''sex  M  F
                   -    0  1''')
sex  M  F
     0  1
>>> from_string('''nat\\sex  M  F
                   BE        0  1
                   FO        2  3''')
nat\sex  M  F
     BE  0  1
     FO  2  3
```

- improved error message when trying to access nonexistent sheet in an Excel workbook (closes issue 266).
- when creating an Axis from a Group and no explicit name was given, reuse the name of the group axis.

```
>>> a = Axis('a=a0..a2')
>>> Axis(a[:'a1'])
Axis(['a0', 'a1'], 'a')
```

- allowed to create an array using a single group as if it was an Axis.

```
>>> a = Axis('a=a0..a2')
>>> ndrange(a)
a  a0  a1  a2
    0   1   2
>>> # using a group as an axis
>>> ndrange(a[:'a1'])
a  a0  a1
    0   1
```

- allowed to use axes (Axis objects) to subset arrays (part of issue 210).

```
>>> arr = ndtest((2, 3))
>>> arr
a\b  b0  b1  b2
 a0   0   1   2
 a1   3   4   5
>>> b2 = Axis('b=b0,b2')
>>> arr[b2]
a\b  b0  b2
 a0   0   2
 a1   3   5
```

- improved string representation of Excel workbooks and sheets (they mention the actual file/sheet they correspond to). This is mostly useful in the interactive console to check what an object corresponds to.

```
>>> wb = open_excel()
>>> wb
<larray.io.excel.Workbook [Book1]>
>>> wb[0]
<larray.io.excel.Sheet [Book1]Sheet1>
```

- open_excel('non existent file') will raise an explicit error immediately when overwrite_file is False, instead of failing at a seemingly random point later on (closes issue 265).
- integer-like strings in axis definition strings using , are converted to integers to be consistent with string definitions using ... In other words, ndrange('a=1,2,3') did not create the same array than ndrange('a=1..3').
- fixed reading a single cell from an Excel sheet.
- fixed script execution not resuming after quitting the viewer when it was called using view(a_single_array).
- fixed opening the viewer after showing a plot window.
- do not display an error when setting the value of an element of a non LArray sequence in the viewer console

```
>>> l = [1, 2, 3]
>>> l[0] = 42
```

6.1.14 Version 0.22

Released on 2017-05-11.

- viewer: added a menu bar with the ability to clear the current session, save all its arrays to a file (.h5, .xlsx, or a directory containing multiple .csv files), and load arrays from such a file (closes issue 88).

  WARNING: Only array objects are currently saved. It means that scalars, functions or others non-LArray objects defined in the console are *not* saved in the file.

- implemented a new describe() method on arrays to give quick summary statistics. By default, it includes the number of non-NaN values, the mean, standard deviation, minimum, 25, 50 and 75 percentiles and maximum.

```
>>> arr = ndrange('gender=Male,Female;year=2014..2020').astype(float)
>>> arr
gender\year | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020
       Male |  0.0 |  1.0 |  2.0 |  3.0 |  4.0 |  5.0 |  6.0
     Female |  7.0 |  8.0 |  9.0 | 10.0 | 11.0 | 12.0 | 13.0
>>> arr.describe()
statistic | count | mean |               std | min |  25% | 50% |  75% |  max
          |  14.0 |  6.5 | 4.031128874149275 | 0.0 | 3.25 | 6.5 | 9.75 | 13.0
```

  an optional keyword argument allows to specify different percentiles to include

```
>>> arr.describe(percentiles=[20, 40, 60, 80])
statistic | count | mean |               std | min | 20% | 40% | 60% |  80% |  max
          |  14.0 |  6.5 | 4.031128874149275 | 0.0 | 2.6 | 5.2 | 7.8 | 10.4 | 13.0
```

  its sister method, describe_by() was also implemented to give quick summary statistics along axes or groups.

```
>>> arr.describe_by('gender')
gender\statistic | count | mean | std | min | 25% |  50% |  75% |  max
            Male |   7.0 |  3.0 | 2.0 | 0.0 | 1.5 |  3.0 |  4.5 |  6.0
          Female |   7.0 | 10.0 | 2.0 | 7.0 | 8.5 | 10.0 | 11.5 | 13.0
>>> arr.describe_by('gender', (x.year[:2015], x.year[2019:]))
gender | year\statistic | count | mean | std |  min |   25% |  50% |   75% |  max
  Male |          :2015 |   2.0 |  0.5 | 0.5 |  0.0 |  0.25 |  0.5 |  0.75 |  1.0
  Male |          2019: |   2.0 |  5.5 | 0.5 |  5.0 |  5.25 |  5.5 |  5.75 |  6.0
Female |          :2015 |   2.0 |  7.5 | 0.5 |  7.0 |  7.25 |  7.5 |  7.75 |  8.0
Female |          2019: |   2.0 | 12.5 | 0.5 | 12.0 | 12.25 | 12.5 | 12.75 | 13.0
```

  This closes issue 184.

- implemented reindex allowing to change the order of labels and add/remove some of them to one or several axes:

```
>>> arr = ndtest((2, 2))
>>> arr
a\b | b0 | b1
 a0 |  0 |  1
 a1 |  2 |  3
>>> arr.reindex(x.b, ['b1', 'b2', 'b0'], fill_value=-1)
a\b | b1 | b2 | b0
 a0 |  1 | -1 |  0
 a1 |  3 | -1 |  2
>>> a = Axis('a', ['a1', 'a2', 'a0'])
>>> b = Axis('b', ['b2', 'b1', 'b0'])
>>> arr.reindex({'a': a, 'b': b}, fill_value=-1)
a\b | b2 | b1 | b0
 a1 | -1 |  3 |  2
 a2 | -1 | -1 | -1
 a0 | -1 |  1 |  0
```

using reindex one can make an array compatible with another array which has more/less labels or with labels in a different order:

```
>>> arr2 = ndtest((3, 3))
>>> arr2
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  2
 a1 |  3 |  4 |  5
 a2 |  6 |  7 |  8
>>> arr.reindex(arr2.axes, fill_value=0)
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  0
 a1 |  2 |  3 |  0
 a2 |  0 |  0 |  0
>>> arr.reindex(arr2.axes, fill_value=0) + arr2
a\b | b0 | b1 | b2
 a0 |  0 |  2 |  2
 a1 |  5 |  7 |  5
 a2 |  6 |  7 |  8
```

This closes issue 18.

- added load_example_data function to load datasets used in tutorial and be able to reproduce examples. The name of the dataset must be provided as argument (there is currently only one available dataset). Datasets are returned as Session objects:

```
>>> demo = load_example_data('demography')
>>> demo.pop.info
26 x 3 x 121 x 2 x 2
 time [26]: 1991 1992 1993 ... 2014 2015 2016
 geo [3]: 'BruCap' 'Fla' 'Wal'
 age [121]: 0 1 2 ... 118 119 120
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
>>> demo.qx.info
26 x 3 x 121 x 2 x 2
 time [26]: 1991 1992 1993 ... 2014 2015 2016
 geo [3]: 'BruCap' 'Fla' 'Wal'
 age [121]: 0 1 2 ... 118 119 120
 sex [2]: 'M' 'F'
 nat [2]: 'BE' 'FO'
```

(closes issue 170)

- implemented Axis.union, intersection and difference which produce new axes by combining the labels of the axis with the other labels.

```
>>> letters = Axis('letters=a,b')
>>> letters.union(Axis('letters=b,c'))
Axis(['a', 'b', 'c'], 'letters')
>>> letters.union(['b', 'c'])
Axis(['a', 'b', 'c'], 'letters')
>>> letters.intersection(['b', 'c'])
Axis(['b'], 'letters')
>>> letters.difference(['b', 'c'])
Axis(['a'], 'letters')
```

- implemented Group.union, intersection and difference which produce new groups by combining the labels of the group with the other labels.

```
>>> letters = Axis('letters=a..d')
>>> letters['a', 'b'].union(letters['b', 'c'])
letters['a', 'b', 'c'].set()
>>> letters['a', 'b'].union(['b', 'c'])
letters['a', 'b', 'c'].set()
>>> letters['a', 'b'].intersection(['b', 'c'])
letters['b'].set()
>>> letters['a', 'b'].difference(['b', 'c'])
letters['a'].set()
```

- viewer: added possibility to delete an array by pressing Delete on keyboard (closes issue 116).
- Excel sheets in workbooks opened via open_excel can be renamed by changing their .name attribute:

```
>>> wb = open_excel()
>>> wb['old_sheet_name'].name = 'new_sheet_name'
```

- Excel sheets in workbooks opened via open_excel can be deleted using "del":

```
>>> wb = open_excel()
>>> del wb['sheet_name']
```

- implemented PGroup.set() to transform a positional group to an LSet.

```
>>> a = Axis('a=a0..a5')
>>> a.i[:2].set()
a['a0', 'a1'].set()
```

- inverted *name* and *labels* arguments when creating an Axis and made *name* argument optional (to create anonymous axes). Now, it is also possible to create an Axis by passing a single string of the kind 'name=labels':

```
>>> anonymous = Axis('0..100')
>>> age = Axis('age=0..100')
>>> gender = Axis('M,F', 'gender')
```

  (closes issue 152)

- renamed Session.dump, dump_hdf, dump_excel and dump_csv to save, to_hdf, to_excel and to_csv (closes issue 217).
- changed default value of *ddof* argument for var and std functions from 0 to 1 (closes issue 190).
- implemented a new syntax for stack(): *stack({label1: value1, label2: value2}, axis)*

```
>>> nat = Axis('nat', 'BE, FO')
>>> sex = Axis('sex', 'M, F')
>>> males = ones(nat)
>>> males
nat |  BE |  FO
    | 1.0 | 1.0
>>> females = zeros(nat)
>>> females
nat |  BE |  FO
    | 0.0 | 0.0
```

  In the case the axis has already been defined in a variable, this gives:

```
>>> stack({'M': males, 'F': females}, sex)
nat\sex |   M |   F
     BE | 1.0 | 0.0
     FO | 1.0 | 0.0
```

Additionally, axis can now be an axis string definition in addition to an Axis object, which means one can write this:

```
>>> stack({'M': males, 'F': females}, 'sex=M,F')
```

It is better than the simpler but *highly discouraged* alternative:

```
>>> stack([males, females), sex)
```

because it is all too easy to invert labels. It is very hard to spot the error in the following line, and larray cannot spot it for you either:

```
>>> stack([females, males), sex)
nat\sex |   M |   F
     BE | 0.0 | 1.0
     FO | 0.0 | 1.0
```

When creating an axis from scratch (it does not already exist in a variable), one might want to use this:

```
>>> stack([males, females], 'sex=M,F')
```

even if this could suffer, to a lesser extent, the same problem as above when stacking many arrays.

- handle ... in transpose method to avoid having to list all axes. This can be useful, for example, to change which axis is displayed in columns (closes issue 188).

```
>>> arr.transpose(..., 'time')
>>> arr.transpose('gender', ..., 'time')
```

- made scalar Groups behave even more like their value: any method available on the value is available on the Group. For example, if the Group has a string value, the string methods are available on it (closes issue 202).

```
>>> test = Axis('test', ['abc', 'a1-a2'])
>>> test.i[0].upper()
'ABC'
>>> test.i[1].split('-')
['a1', 'a2']
```

- updated AxisCollection.replace so as to replace one, several or all axes and to accept axis definitions as new axes.

```
>>> arr = ndtest((2, 3))
>>> axes = arr.axes
>>> axes
AxisCollection([
    Axis(['a0', 'a1'], 'a'),
    Axis(['b0', 'b1', 'b2'], 'b')
])
>>> row = Axis(['r0', 'r1'], 'row')
>>> column = Axis(['c0', 'c1', 'c2'], 'column')
```

Replace several axes (keywords, list of tuple or dictionary)

```
>>> axes.replace(a=row, b=column)
>>> # or
>>> axes.replace(a="row=r0,r1", b="column=c0,c1,c2")
>>> # or
>>> axes.replace([(x.a, row), (x.b, column)])
>>> # or
>>> axes.replace({x.a: row, x.b: column})
AxisCollection([
    Axis(['r0', 'r1'], 'row'),
    Axis(['c0', 'c1', 'c2'], 'column')
])
```

- added possibility to delete an array from a session:

```
>>> s = Session({'a': ndtest((3, 3)), 'b': ndtest((2, 4)), 'c': ndtest((4, 2))})
>>> s.names
['a', 'b', 'c']
>>> del s.b
>>> del s['c']
>>> s.names
['a']
```

- made create_sequential axis argument accept axis definitions in addition to Axis objects like, for example, using a string definition (closes issue 160).

```
>>> create_sequential('year=2016..2019')
year | 2016 | 2017 | 2018 | 2019
     |    0 |    1 |    2 |    3
```

- replaced *args, **kwargs by explicit arguments in documentation of aggregation functions (sum, prod, mean, std, var, …). Closes issue 41.
- improved documentation of plot method (closes issue 169).
- improved auto-completion in ipython interactive consoles for both LArray and Session objects. LArray objects can now complete keys within [].

```
>>> a = ndrange('sex=Male,Female')
>>> a
sex | Male | Female
    |    0 |      1
>>> a['Fe<tab>`
```

will autocomplete to *a['Female*. Sessions will now auto-complete both attributes (using *session.*) and keys (using *session[*).

```
>>> s = Session({'a_nice_test_array': ndtest(10)})
>>> s.a_<tab>
```

will autocomplete to *s.a_nice_test_array* and *s['a_<tab>* will be completed to *s['a_nice_test_array*

- made warning messages for division by 0 and invalid values (usually caused by 0 / 0) point to the user code line, instead of the corresponding line in the larray module.
- preserve order of arrays in a session when saving to/loading from an .xlsx file.
- when creating a session from a directory containing CSV files, the directory may now contain other (non-CSV) files.

- several calls to open_excel from within the same program/script will now reuses a single global Excel instance. This makes Excel I/O much faster without having to create an instance manually using xlwings.App, and still without risking interfering with other instances of Excel opened manually (closes issue 245).
- improved error message when trying to copy a sheet from one instance of Excel to another (closes issue 231).
- fixed keyword arguments such as *out*, *ddof*, ... for aggregation functions (closes issue 189).
- fixed percentile(_by) with multiple percentiles values, i.e. when argument *q* is a list/tuple (closes issue 192).
- fixed group aggregates on integer arrays for median, percentile, var and std (closes issue 193).
- fixed group sum over boolean arrays (closes issue 194).
- fixed set_labels when inplace=True.
- fixed array creation functions not raising an exception when called with wrong syntax func(axis1, axis2, ...) instead of func([axis1, axis2, ...]) (closes issue 203).
- fixed position of added sheets in excel workbook: new sheets are appended instead of prepended (closes issue 229).
- fixed Workbook behavior in case of new workbook: the first added sheet replaces the default sheet *Sheet1* (closes issue 230).
- fixed name of Workbook sheets created by copying another sheet (closes issue 244).

```
>>> wb = open_excel()
>>> wb['name_of_new_sheet'] = wb['name_of_sheet_to_copy']
```

- fixed with_axes warning to refer to set_axes instead of replace_axes.
- fixed displayed title in viewer: shows path to file associated with current session + current array info + extra info (closes issue 181)

6.1.15 Version 0.21

Released on 2017-03-28.

- implemented set_axes() method to replace one, several or all axes of an array (closes issue 67). The method with_axes() is now deprecated (set_axes() must be used instead).

```
>>> arr = ndtest((2, 3))
>>> arr
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  2
 a1 |  3 |  4 |  5
>>> row = Axis('row', ['r0', 'r1'])
>>> column = Axis('column', ['c0', 'c1', 'c2'])
```

Replace one axis (second argument *new_axis* must be provided)

```
>>> arr.set_axes(x.a, row)
row\b | b0 | b1 | b2
   r0 |  0 |  1 |  2
   r1 |  3 |  4 |  5
```

Replace several axes (keywords, list of tuple or dictionary)

```
>>> arr.set_axes(a=row, b=column)
or
>>> arr.set_axes([(x.a, row), (x.b, column)])
or
>>> arr.set_axes({x.a: row, x.b: column})
row\column | c0 | c1 | c2
        r0 |  0 |  1 |  2
        r1 |  3 |  4 |  5
```

Replace all axes (list of axes or AxisCollection)

```
>>> arr.set_axes([row, column])
row\column | c0 | c1 | c2
        r0 |  0 |  1 |  2
        r1 |  3 |  4 |  5
>>> arr2 = ndrange([row, column])
>>> arr.set_axes(arr2.axes)
row\column | c0 | c1 | c2
        r0 |  0 |  1 |  2
        r1 |  3 |  4 |  5
```

- implemented Axis.replace to replace some labels from an axis:

```
>>> sex = Axis('sex', ['M', 'F'])
>>> sex
Axis('sex', ['M', 'F'])
>>> sex.replace('M', 'Male')
Axis('sex', ['Male', 'F'])
>>> sex.replace({'M': 'Male', 'F': 'Female'})
Axis('sex', ['Male', 'Female'])
```

- implemented from_string() method to create an array from a string (closes issue 96).

```
>>> from_string('''age,nat\\sex, M, F
...                0,  BE,       0, 1
...                0,  FO,       2, 3
...                1,  BE,       4, 5
...                1,  FO,       6, 7''')
age | nat\sex | M | F
  0 |      BE | 0 | 1
  0 |      FO | 2 | 3
  1 |      BE | 4 | 5
  1 |      FO | 6 | 7
```

- allowed to use a regular expression in split_axis method (closes issue 106):

```
>>> combined = ndrange('a_b = a0b0..a1b2')
>>> combined
a_b | a0b0 | a0b1 | a0b2 | a1b0 | a1b1 | a1b2
    |    0 |    1 |    2 |    3 |    4 |    5
>>> combined.split_axis(x.a_b, regex='(\w{2})(\w{2})')
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  2
 a1 |  3 |  4 |  5
```

- one can assign a new axis to several groups at the same time by using axis[groups]:

```
>>> group1 = year[2001:2004]
>>> group2 = year[2008,2009]
>>> # let us change the year axis by time
>>> x.time[group1, group2]
(x.time[2001:2004], x.time[2008, 2009])
```

- implemented Axis.by() which is equivalent to axis[:].by() and divides the axis into several groups of specified length:

```
>>> year = Axis('year', '2010..2016')
>>> year.by(3)
(year.i[0:3], year.i[3:6], year.i[6:7])
```

  which is equivalent to (year[2010:2012], year[2013:2015], year[2016]). Like for groups, the optional second argument specifies the step between groups

```
>>> year.by(3, step=4)
(year.i[0:3], year.i[4:7])
```

  which is equivalent to (year[2010:2012], year[2014:2016]). And if step is smaller than length, we get overlapping groups, which can be useful for example for moving averages.

```
>>> year.by(3, 2)
(year.i[0:3], year.i[2:5], year.i[4:7], year.i[6:7])
```

  which is equivalent to (year[2010:2012], year[2012:2014], year[2014:2016], year[2016])

- implemented larray_nan_equal to test whether two arrays are identical even in the presence of nan values. Two arrays are considered identical by larray_equal if they have exactly the same axes and data. However, since a nan value has the odd property of not being equal to itself, larray_equal returns False if either array contains a nan value. larray_nan_equal returns True if all not-nan data is equal and both arrays have nans at the same place.

```
>>> arr1 = ndtest((2, 3), dtype=float)
>>> arr1['a1', 'b1'] = nan
>>> arr1
a\b |  b0 |  b1 |  b2
 a0 | 0.0 | 1.0 | 2.0
 a1 | 3.0 | nan | 5.0
>>> arr2 = arr1.copy()
>>> arr2
a\b |  b0 |  b1 |  b2
 a0 | 0.0 | 1.0 | 2.0
 a1 | 3.0 | nan | 5.0
>>> larray_equal(arr1, arr2)
False
>>> larray_nan_equal(arr1, arr2)
True
>>> arr2['b1'] = 0.0
>>> larray_nan_equal(arr1, arr2)
False
```

- viewer: make keyboard shortcuts work even when the focus is not on the array editor widget. It means that, for example, plotting an array (via Ctrl-P) or opening it in Excel (Ctrl-E) can be done directly even when interacting with the list of arrays or within the interactive console (closes issue 102).
- viewer: automatically display plots done in the viewer console in a separate window (see example below), unless "%matplotlib inline" is used.

```
>>> arr = ndtest((3, 3))
>>> arr.plot()
```

- viewer: when calling view(an_array) from within the viewer, the new window opened does not block the initial window, which means you can have several windows open at the same time. view() without argument can still result in odd behavior though.
- improved LArray.set_labels to make it possible to replace only some labels of an axis, instead of all of them and to replace labels from several axes at the same time.

```
>>> a = ndrange('nat=BE,FO;sex=M,F')
>>> a
nat\sex | M | F
     BE | 0 | 1
     FO | 2 | 3
```

to replace only some labels, one must give a mapping giving the new label for each label to replace

```
>>> a.set_labels(x.sex, {'M': 'Men'})
nat\sex | Men | F
     BE |   0 | 1
     FO |   2 | 3
```

to replace labels for several axes at the same time, one should give a mapping giving the new labels for each changed axis

```
>>> a.set_labels({'sex': 'Men,Women', 'nat': 'Belgian,Foreigner'})
  nat\sex | Men | Women
  Belgian |   0 |     1
Foreigner |   2 |     3
```

one can also replace some labels in several axes by giving a mapping of mappings

```
>>> a.set_labels({'sex': {'M': 'Men'}, 'nat': {'BE': 'Belgian'}})
nat\sex | Men | F
Belgian |   0 | 1
     FO |   2 | 3
```

- allowed matrix multiplication (@ operator) between arrays with dimension != 2 (closes issue 122).
- improved LArray.plot to get nicer plots by default. The axes are transposed compared to what they used to, because the last axis is often used for time series. Also it considers a 1D array like a single series, not N series of 1 point.
- added installation instructions (closes issue 101).
- Axis.group and Axis.all are now deprecated (closes issue 148).

```
>>> city.group(['London', 'Brussels'], name='capitals')
# should be written as:
>>> city[['London', 'Brussels']] >> 'capitals'
```

and

```
>>> city.all()
# should be written as:
>>> city[:] >> 'all'
```

- viewer: allow changing the number of displayed digits even for integer arrays as that makes sense when using scientific notation (closes issue 100).
- viewer: fixed opening a viewer via view() edit() or compare() from within the viewer (closes issue 109)
- viewer: fixed compare() colors when arrays have values which are very close but not exactly equal (closes issue 123)
- viewer: fixed legend when plotting arbitrary rows (it always displayed the labels of the first rows) (closes issue 136).
- viewer: fixed labels on the x axis when zooming on a plot (closes issue 143)
- viewer: fixed storing an array in a variable with a name which existed previously but which was not displayable in the viewer, such as the name of any function or special object. In some cases, this error lead to a crash of the viewer. For example, this code failed when run in the viewer console, because x is already defined (for the x. syntax):

```
>>> x = ndtest(3)
```

- fixed indexing an array using a positional group with a position which corresponds to a label on that axis. This used to return the wrong data (the data corresponding to the position as if it was the key).

```
>>> a = Axis('a', '1..3')
>>> arr = ndrange(a)
>>> arr
a | 1 | 2 | 3
  | 0 | 1 | 2
>>> # this used to return 0 !
>>> arr[a.i[1]]
1
```

- fixed == for positional groups (closes issue 93)

```
>>> years = Axis('years', '1995..1997')
>>> years
Axis('years', [1995, 1996, 1997])
>>> # this used to return False
>>> years.i[0] == 1995
True
```

- fixed using positional groups for their value in many cases (slice bounds, within list of values, within other groups, etc.). For example, this used to fail:

```
>>> arr = ndtest((2, 4))
>>> arr
a\b | b0 | b1 | b2 | b3
 a0 |  0 |  1 |  2 |  3
 a1 |  4 |  5 |  6 |  7
>>> b = arr.b
>>> start = b.i[0]  # equivalent to start = 'b0'
>>> stop = b.i[2]   # equivalent to stop = 'b2'
>>> arr[start:stop]
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  2
 a1 |  4 |  5 |  6
>>> arr[[b.i[0], b.i[2]]]
a\b | b0 | b2
```

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```
a0 |  0 |  2
a1 |  4 |  6
```

- fixed posargsort labels (closes issue 137).
- fixed labels when doing group aggregates using positional groups. Previously, it used the positions as labels. This was most visible when using the Group.by() method (which creates positional groups).

```
>>> years = Axis('years', '2010..2015')
>>> arr = ndrange(years)
>>> arr
years | 2010 | 2011 | 2012 | 2013 | 2014 | 2015
      |    0 |    1 |    2 |    3 |    4 |    5
>>> arr.sum(years.by(3))
years | 2010:2012 | 2013:2015
      |         3 |        12
```

While this used to return:

```
>>> arr.sum(years.by(3))
years | 0:3 | 3:6
      |   3 |  12
```

- fixed Group.by() when the group was a slice with either bound unspecified. For example, *years[2010:2015].by(3)* worked but *years[:].by(3)*, *years[2010:].by(3)* and *years[:2015].by(3)* did not.
- fixed a speed regression in version 0.18 and later versions compared to 0.17. In some cases, it was up to 40% slower than it should (closes issue 165).

6.1.16 Version 0.20

Released on 2017-02-09.

To make sure all users have all optional dependencies installed and use the same version of packages, and to simplify the update process, we created a new "larrayenv" package which will install larray itself AND all its dependencies (*including* the optional ones). This means that this version needs to be installed using:

conda install larrayenv

in the future, to update from one version to the next, it should always be enough to do:

conda update larrayenv

- implemented from_lists() to create constant arrays (instead of using LArray directly as that is very error prone). We are not really happy with its name though, so it might change in the future. Any suggestion of a better name is very welcome (closes issue 30).

```
>>> from_lists([['sex\\year', 1991, 1992, 1993],
...             [ 'M',           0,    1,    2],
...             [ 'F',           3,    4,    5]])
sex\year | 1991 | 1992 | 1993
       M |    0 |    1 |    2
       F |    3 |    4 |    5
```

- added support for loading sparse arrays via open_excel().

  For example, assuming you have a sheet like this:

```
age | sex\year | 2015 | 2016
 10 |        F |  0.0 |  1.0
 10 |        M |  2.0 |  3.0
 20 |        M |  4.0 |  5.0
```

loading it will yield:

```
>>> wb = open_excel('test_sparse.xlsx')
>>> arr = wb['Sheet1'].load()
>>> arr
age | sex\year | 2015 | 2016
 10 |        F |  0.0 |  1.0
 10 |        M |  2.0 |  3.0
 20 |        F |  nan |  nan
 20 |        M |  4.0 |  5.0
```

- allowed to get an axis from an array by using array.axis_name in addition to array.axes.axis_name:

```
>>> arr = ndtest((2, 3))
>>> arr.axes
AxisCollection([
    Axis('a', ['a0', 'a1']),
    Axis('b', ['b0', 'b1', 'b2'])
])
>>> arr.a
Axis('a', ['a0', 'a1'])
```

- viewer: several rows/columns can be plotted together. It draws a separate line for each row except if only one column has been selected.
- viewer: the array labels are used as "ticks" in plots.
- '_by' aggregation methods accept groups in addition to axes (closes issue 59). It will keep only the mentioned groups and aggregate all other dimensions:

```
>>> arr = ndtest((2, 3, 4))
>>> arr
 a | b\c | c0 | c1 | c2 | c3
a0 |  b0 |  0 |  1 |  2 |  3
a0 |  b1 |  4 |  5 |  6 |  7
a0 |  b2 |  8 |  9 | 10 | 11
a1 |  b0 | 12 | 13 | 14 | 15
a1 |  b1 | 16 | 17 | 18 | 19
a1 |  b2 | 20 | 21 | 22 | 23
```

```
>>> arr.sum_by('c0,c1;c1:c3')
c | c0,c1 | c1:c3
  |   126 |   216
```

- viewer: view() and edit() now accept as argument a path to a file containing arrays.

```
>>> view('myfile.h5')
```

this is a shortcut for:

```
>>> view(Session('myfile.h5'))
```

- AxisCollection.without now accepts a single integer position (to exclude an axis by position).

```
>>> a = ndtest((2, 3))
>>> a.axes
AxisCollection([
    Axis('a', ['a0', 'a1']),
    Axis('b', ['b0', 'b1', 'b2'])
])
>>> a.axes.without(0)
AxisCollection([
    Axis('b', ['b0', 'b1', 'b2'])
])
```

- nicer display (repr) for LSet (closes issue 44).

```
>>> x.b['b0,b2'].set()
x.b['b0', 'b2'].set()
```

- implemented sep argument for LArray & AxisCollection.combine_axes() to allow using a custom delimiter (closes issue 53).
- added a check that ipfp target sums haves expected axes (closes issue 42).
- when the nb_index argument is not provided explicitly in read_excel(engine='xlrd'), it is autodetected from the position of the first "" (closes issue 66).
- allow any special character except "." and whitespace when creating axes labels using ".." syntax (previously only _ was allowed).
- added many more I/O tests to hopefully lower our regression rate in the future (closes issue 70).
- viewer: selection of entire rows/columns will load any remaining data, if any (closes issue 37). Previously if you selected entire rows or columns of a large dataset (which is not loaded entirely from the start), it only selected (and thus copied/plotted) the part of the data which was already loaded.
- viewer: filtering on anonymous axes is now possible (closes issue 33).
- fixed loading sparse files using read_excel() (fixes issue 29).
- fixed nb_index argument for read_excel().
- fixed creating range axes with a negative start bound using string notation (e.g. *Axis('name', '-1..10')*) (fixes issue 51).
- fixed ptp() function.
- fixed with_axes() to copy the title of the array.
- fixed Group >> 'name'.
- fixed workbook[sheet_position] when using open_excel().
- fixed plotting in the viewer when using Qt4.

6.1.17 Version 0.19

Released on 2017-01-19.

- Implemented a "by" variant to all aggregate methods (e.g. sum_by, mean_by, etc.). These methods aggregate all axes except those listed, which means the only axes remaining after the aggregate operation will be those listed. For example: arr.sum_by(x.a) is equivalent to arr.sum(arr.axes - x.a)

```
>>> arr = ndtest((2, 3, 4))
>>> arr
 a  | b\c | c0 | c1 | c2 | c3
a0  |  b0 |  0 |  1 |  2 |  3
a0  |  b1 |  4 |  5 |  6 |  7
a0  |  b2 |  8 |  9 | 10 | 11
a1  |  b0 | 12 | 13 | 14 | 15
a1  |  b1 | 16 | 17 | 18 | 19
a1  |  b2 | 20 | 21 | 22 | 23
>>> arr.sum_by(x.b)
b | b0 | b1 |  b2
  | 60 | 92 | 124
```

- Added .extend() method to Axis class

```
>>> a = Axis('a', 'a0..a2')
>>> a
Axis('a', ['a0', 'a1', 'a2'])
>>> other = Axis('other', 'a3..a5')
>>> a.extend(other)
Axis('a', ['a0', 'a1', 'a2', 'a3', 'a4', 'a5'])
```

or directly specify the extra labels as a list or as a "label string":

```
>>> a.extend('a3..a5')
Axis('a', ['a0', 'a1', 'a2', 'a3', 'a4', 'a5'])
```

- Added title argument to all array creation functions (ndrange, zeros, ones, . . .) and display it in the .info of array objects.

```
>>> a = ndrange(3, title='a simple test array')
>>> a.info
a simple test array
3
 {0}* [3]: 0 1 2
```

- implemented creating an Axis using a group:

```
>>> arr = ndtest((2, 3))
>>> arr
a\b | b0 | b1 | b2
a0  |  0 |  1 |  2
a1  |  3 |  4 |  5
>>> a, b = arr.axes
>>> zeros((a, b[:'b1']))
a\b |  b0 |  b1
a0  | 0.0 | 0.0
a1  | 0.0 | 0.0
```

- made Axis.startswith, .endswith and .matches accept Group instances

```
>>> a = Axis('a', 'a0..b2')
>>> a
Axis('a', ['a0', 'a1', 'a2', 'b0', 'b1', 'b2'])
```

```
>>> prefix = Axis('prefix', 'a,b')
>>> a.startswith(prefix['a'])
```

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```
a['a0', 'a1', 'a2']
>>> a.startswith(prefix.i[1])
a['b0', 'b1', 'b2']
```

- implemented all usual binary operations (+, -, *, /, . . .) on Group

```
>>> year = Axis('year', '2011..2016')
>>> year[2013] + 1
2014
>>> year.i[2] + 1
2014
```

- made the viewer is much more useful as a debugger in the middle of a function by generalizing SessionEditor to handle any mapping, instead of only Session objects but made it list and display only array objects. To view the value of non-array variable one should type their name in the console. Given those changes, view() will superficially behave as before, but behind the scene, *all* variables which were defined in the scope where view() was called will be available in the viewer console, even though they will not appear in the list on the left. This means that the viewer console will be able to use scalars defined at that point and call others functions of your code. In other words, there are more chances you can execute some code from the function calling view() by simply copy-pasting the code line.
- LGroup lost set-like operations (intersection and union) to the profit of a specific subclass (LSet). In other words, this no longer works:

```
>>> letters = Axis('letters', 'a..z')
>>> letters[':c'] & letters['b:']
```

To make it work, we need to convert the LGroup(s) to LSets explicitly:

```
>>> letters[':c'].set() & letters['b:d'].set()
letters.set[OrderedSet(['b', 'c'])]
```

```
>>> letters[':c'].set() | letters['b:d'].set()
letters.set[OrderedSet(['a', 'b', 'c', 'd'])]
```

```
>>> letters[':c'].set() - 'b'
letters.set[OrderedSet(['a', 'c'])]
```

- group aggregates produce simple string labels for the new aggregated axis instead of using the group themselves as labels. This means one can no longer know where a group comes from but this simplifies the code and fixes a few issues, most notably export of aggregated arrays to Excel, and some operations between two aggregated arrays.

```
>>> arr = ndtest((3, 4))
>>> arr
a\b | b0 | b1 | b2 | b3
 a0 |  0 |  1 |  2 |  3
 a1 |  4 |  5 |  6 |  7
 a2 |  8 |  9 | 10 | 11
>>> agg = arr.sum(':b2 >> tob2;b2,b3 >> other')
>>> agg
a\b | tob2 | other
 a0 |    3 |     5
 a1 |   15 |    13
 a2 |   27 |    21
```

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```
>>> agg.info
3 x 2
 a [3]: 'a0' 'a1' 'a2'
 b [2]: 'tob2' 'other'
>>> agg.axes.b.labels[0]
'tob2'
```

In previous versions this would have returned:

```
>>> agg.axes.b.labels[0]
LGroup(':b2', name='tob2', axis=Axis('b', ['b0', 'b1', 'b2', 'b3']))
```

- a string containing only a single "integer-like" is no longer transformed to an integer e.g. "10" will evaluate to (the string) "10" (like in version 0.17 and earlier) while "10,20" will evaluate to the list of integers: [10, 20]
- changed how Group instances are displayed.

```
>>> a = Axis('a', 'a0..a2')
>>> a['a1,a2']
a['a1', 'a2']
```

- fixed > and >= on Group using slices
- avoid a division by 0 warning when using divnot0
- viewer: fixed plots when Qt5 is installed. This also removes the matplotlib warning people got when running the viewer with Qt5 installed.
- viewer: display array when typing its name in the console even when no array was selected previously
- misc code cleanup, improved docstrings, …

6.1.18 Version 0.18

Released on 2016-12-20.

- the documentation (docstrings) of many functions was vastly improved (thanks to Alix)
- implemented a new optional syntax to generate sequences of labels for axes by using patterns

  integer strings generate integers

```
>>> ndrange('age=0..10')
age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10
    | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10
```

  you can combine letters and numbers. The number part is treated like increasing (or decreasing numbers)

```
>>> ndrange('lipro=P01..P12')
lipro | P01 | P02 | P03 | P04 | P05 | P06 | P07 | P08 | P09 | P10 | P11 | P12
      |   0 |   1 |   2 |   3 |   4 |   5 |   6 |   7 |   8 |   9 |  10 |  11
```

  letter patterns generate all combination of letters between the start and end:

```
>>> ndrange('test=AA..CC')
test | AA | AB | AC | BA | BB | BC | CA | CB | CC
     |  0 |  1 |  2 |  3 |  4 |  5 |  6 |  7 |  8
```

  other characters are left intact (and should be the same on the start and end patterns:

```
>>> ndrange('test=A_1..C_2')
test  | A_1 | A_2 | B_1 | B_2 | C_1 | C_2
      |   0 |   1 |   2 |   3 |   4 |   5
```

this also works within Axis()

```
>>> Axis('age', '0..10')
Axis('age', [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10])
```

- implemented new syntax for defining groups using strings:

```
>>> arr = ndtest((3, 4))
>>> arr
a\b | b0 | b1 | b2 | b3
 a0 |  0 |  1 |  2 |  3
 a1 |  4 |  5 |  6 |  7
 a2 |  8 |  9 | 10 | 11
```

groups can be named using ">>" instead of "=" previously

```
>>> arr.sum('b1,b3 >> b13;b0:b2 >> b012')
a\b | b13 | b012
 a0 |   4 |    3
 a1 |  12 |   15
 a2 |  20 |   27
```

if some labels are ambiguous, one can specify the axis by using "axis_name[labels]":

```
>>> arr.sum('b[b1,b3] >> b13;b[b0:b2] >> b012')
a\b | b13 | b012
 a0 |   4 |    3
 a1 |  12 |   15
 a2 |  20 |   27
```

groups can also be defined by position using this syntax:

```
>>> arr.sum('b.i[1,3] >> b13;b.i[0:3] >> b012')
a\b | b13 | b012
 a0 |   4 |    3
 a1 |  12 |   15
 a2 |  20 |   27
```

A few notes:

  - the goal was to have that syntax as close as the "normal" syntax as possible (just remove the "x." and all inner quotes).
  - in models, the normal syntax should be preferred, so that the groups can be stored in a variable and reused in several places
  - strings representing integers are evaluated as integers.
  - there is experimental support for evaluating expressions within string groups by using "{expr}", but this is fragile and might be removed in the future.

- implemented combine_axes & split_axis on arrays:

```
>>> arr = ndtest((2, 3, 4))
>>> arr
 a  | b\c  | c0  | c1  | c2  | c3
a0  |  b0  |  0  |  1  |  2  |  3
a0  |  b1  |  4  |  5  |  6  |  7
a0  |  b2  |  8  |  9  | 10  | 11
a1  |  b0  | 12  | 13  | 14  | 15
a1  |  b1  | 16  | 17  | 18  | 19
a1  |  b2  | 20  | 21  | 22  | 23
```

```
>>> arr2 = arr.combine_axes((x.a, x.b))
>>> arr2
a_b\c  | c0  | c1  | c2  | c3
a0_b0  |  0  |  1  |  2  |  3
a0_b1  |  4  |  5  |  6  |  7
a0_b2  |  8  |  9  | 10  | 11
a1_b0  | 12  | 13  | 14  | 15
a1_b1  | 16  | 17  | 18  | 19
a1_b2  | 20  | 21  | 22  | 23
```

```
>>> arr2.split_axis(x.a_b)
 a  | b\c  | c0  | c1  | c2  | c3
a0  |  b0  |  0  |  1  |  2  |  3
a0  |  b1  |  4  |  5  |  6  |  7
a0  |  b2  |  8  |  9  | 10  | 11
a1  |  b0  | 12  | 13  | 14  | 15
a1  |  b1  | 16  | 17  | 18  | 19
a1  |  b2  | 20  | 21  | 22  | 23
```

- implemented .by() method on groups which splits them into subgroups of specified length

```
>>> arr = ndtest((5, 2))
>>> arr
a\b  | b0  | b1
 a0  |  0  |  1
 a1  |  2  |  3
 a2  |  4  |  5
 a3  |  6  |  7
 a4  |  8  |  9
```

```
>>> arr.sum(a['a0':'a4'].by(2))
         a\b  | b0  | b1
a['a0' 'a1']  |  2  |  4
a['a2' 'a3']  | 10  | 12
     a['a4']  |  8  |  9
```

there is also an optional second argument to specify the "step" between groups

```
>>> arr.sum(a['a0':'a4'].by(2, step=3))
         a\b  | b0  | b1
a['a0' 'a1']  |  2  |  4
a['a3' 'a4']  | 14  | 16
```

if the step is < the group size, you get overlapping groups:

```
>>> arr.sum(a['a0':'a4'].by(2, step=1))
         a\b | b0 | b1
a['a0' 'a1'] |  2 |  4
a['a1' 'a2'] |  6 |  8
a['a2' 'a3'] | 10 | 12
a['a3' 'a4'] | 14 | 16
     a['a4'] |  8 |  9
```

- groups can be renamed using >> (in addition to the "named" method)

```
>>> arr = ndtest((2, 3))
>>> arr
a\b | b0 | b1 | b2
 a0 |  0 |  1 |  2
 a1 |  3 |  4 |  5
>>> arr.sum((x.b['b0,b1'] >> 'b01', x.b['b1,b2'] >> 'b12'))
a\b | b01 | b12
 a0 |   1 |   3
 a1 |   7 |   9
```

- implemented rationot0

```
>>> a = Axis('a', 'a0,a1')
>>> b = Axis('b', 'b0,b1,b2')
>>> arr = LArray([[6, 0, 2],
...               [4, 0, 8]], [a, b])
>>> arr
a\b | b0 | b1 | b2
 a0 |  6 |  0 |  2
 a1 |  4 |  0 |  8
>>> arr.sum()
20
>>> arr.rationot0()
a\b |  b0 |  b1 |  b2
 a0 | 0.3 | 0.0 | 0.1
 a1 | 0.2 | 0.0 | 0.4
>>> arr.rationot0(x.a)
a\b |  b0 |  b1 |  b2
 a0 | 0.6 | 0.0 | 0.2
 a1 | 0.4 | 0.0 | 0.8
```

for reference, the normal ratio method would return:

```
>>> arr.ratio(x.a)
a\b |  b0 |  b1 |  b2
 a0 | 0.6 | nan | 0.2
 a1 | 0.4 | nan | 0.8
```

- implemented [] on groups so that you can further subset them
- added a new "condensed" option for ipfp's display_progress argument to get back the old behavior
- changed how named groups are displayed (only the name is displayed)
- positional groups gained a few features and are almost on par with label groups now
- when iterating over an axis (for example when doing "for y in year_axis:" it yields groups (instead of raw labels) so that it works even in the presence of ambiguous labels.

- Axis.startswith, endswith, matches create groups which include the axis (so that those groups work even if the labels exist on several axes)
- fixed Session.summary() when arrays in the session have axes without name
- fixed full() and full_like() with an explicit dtype (the dtype was ignored)

6.1.19 Version 0.17

Released on 2016-11-29.

- added ndtest function to create n-dimensional test arrays (of given shape). Axes are named by single letters starting from 'a'. Axes labels are constructed using a '{axis_name}{label_pos}' pattern (e.g. 'a0').

```
>>> ndtest(6)
a | a0 | a1 | a2 | a3 | a4 | a5
  |  0 |  1 |  2 |  3 |  4 |  5
>>> ndtest((2, 3))
a\b | b0 | b1 | b2
a0  |  0 |  1 |  2
a1  |  3 |  4 |  5
>>> ndtest((2, 3), label_start=1)
a\b | b1 | b2 | b3
a1  |  0 |  1 |  2
a2  |  3 |  4 |  5
```

- allow naming "one-shot" groups in group aggregates.

```
>>> arr = ndtest((2, 3))
>>> arr
a\b | b0 | b1 | b2
a0  |  0 |  1 |  2
a1  |  3 |  4 |  5
>>> arr.sum('g1=b0;g2=b1,b2;g3=b0:b2')
a\b | 'g1' ('b0') | 'g2' (['b1' 'b2']) | 'g3' ('b0':'b2')
a0  |           0 |                  3 |                3
a1  |           3 |                  9 |               12
```

- implemented argmin, argmax, posargmin, posargmax without an axis argument (works on the full array).

```
>>> arr = ndtest((2, 3))
>>> arr
a\b | b0 | b1 | b2
a0  |  0 |  1 |  2
a1  |  3 |  4 |  5
>>> arr.argmin()
('a0', 'b0')
```

- added preliminary code to add a title attribute to LArray.

  This needs a lot more work to be really useful though, as it can currently only be used in the LArray() function itself and is only used in Session.summary() (see below). There are many places where this should be used, but this is not done yet.

- added Session.summary() which displays a list of all arrays, their dimension names and title if any.

  This can be used in combination with local_arrays() to produce some kind of codebook with all the arrays of a function.

```
>>> arr = LArray([[1, 2], [3, 4]], 'sex=M,F;nat=BE,FO', title='a test array')
>>> arr
sex\nat | BE | FO
      M |  1 |  2
      F |  3 |  4
>>> s = Session({'arr': arr})
>>> s
Session(arr)
>>> print(s.summary())
arr: sex, nat
    a test array
```

- fixed using groups from other (compatible) axis
- fixed group aggregates using groups without axis
- fixed axis[another_label_group] when said group had a non-string Axis
- fixed axis.group(another_label_group, name='a_name') (name was not set correctly)
- fixed ipfp progress message when progress is negative
- when setting part of an array in the console (by using e.g. arr['M'] = 10), display that array
- when typing in the console the name of an existing array, select it in the list
- fixed missing tooltips for arrays added to the session from within the session viewer
- fixed window title (with axes info) not updating in many cases
- fixed the filters bar not being cleared when displaying a non-LArray object after an LArray object
- improved messages in ipfp(display_progress=True)
- improved tests, docstrings, …

6.1.20 Version 0.16.1

Released on 2016-11-04.

- renamed "Ok" button in array/session viewer to "Close".
- added apply and discard buttons in session editor, which permanently apply or discard changes to the current array.
- fixed array[sequence, scalar] = value
- fixed array.to_excel() which was broken in 0.16 (by the upgrade to xlwings 0.9+).
- improved a few tests

6.1.21 Version 0.16

Released on 2016-10-26.

Warning: this release needs to be installed using:

conda update larray conda update xlwings

- implemented support for xlwings 0.9+. This allowed us to change the way we interact with Excel:
  - by default, the Excel instance we use is configured to be both hidden and silent (for example, it does not prompt to update/edit links).

- by default, we now use a dedicated Excel instance for each call to open_excel, instead of reusing any existing instance if there was any open. In practice, it means input/output from/to Excel is more reliable and does not risk altering any workbook you had open (except if you ask for that explicitly). The cost of this is that it is slower by default. If you open many different workbooks, it is recommended that you create a single Excel instance and reuse it. This can be done with:

```
>>> from larray import *
>>> import xlwings as xw
```

```
>>> app = xw.App(visible=False, add_book=False)
>>> wb1 = open_excel('workbook1.xlsx', app=app)
# use wb1 as before
>>> wb1.close()
>>> wb2 = open_excel('workbook2.xlsx', app=app)
# use wb2 as before
>>> wb2.close()
>>> app.quit()
```

- added ipfp function which does Iterative Proportional Fitting Procedure (also known as bi-proportional fitting in statistics or RAS algorithm in economics). Note that this new function is currently not in the core module, so it needs a specific import command:

```
>>> from larray.ipfp import ipfp
```

```
>>> a = Axis('a', 2)
>>> b = Axis('b', 2)
>>> initial = LArray([[2, 1],
...                   [1, 2]], [a, b])
>>> initial
a*\b* | 0 | 1
    0 | 2 | 1
    1 | 1 | 2
>>> target_sum_along_a = LArray([2, 1], b)
>>> target_sum_along_b = LArray([1, 2], a)
>>> ipfp([target_sum_along_a, target_sum_along_b], initial, threshold=0.01)
a*\b* |                  0 |                    1
    0 | 0.8450704225352113 | 0.15492957746478875
    1 | 1.1538461538461537 |  0.8461538461538463
```

- made it possible to create arrays more succintly in some usual cases (especially for quick arrays for testing purposes). Previously, when one created an array from scratch, he had to provide Axis object(s) (or another array). Note that the following examples use zeros() but this change affects all array creation functions (ones, zeros, ndrange, full, empty):

```
>>> nat = Axis('nat', ['BE', 'FO'])
>>> sex = Axis('sex', ['M', 'F'])
>>> zeros([nat, sex])
nat\sex |   M |   F
     BE | 0.0 | 0.0
     FO | 0.0 | 0.0
```

Now, when you have axe names and axes labels but do not have/want to reuse an existing axis, you can use this syntax:

```
>>> zeros([('nat', ['BE', 'FO']),
...        ('sex', ['M', 'F'])])
```

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```
nat\sex |   M |   F
     BE | 0.0 | 0.0
     FO | 0.0 | 0.0
```

If additionally all axe names and labels are strings (not integers or other types) which do not contain any special character ("=", "," or ";") you can use:

```
>>> zeros('nat=BE,FO;sex=M,F')
nat\sex |   M |   F
     BE | 0.0 | 0.0
     FO | 0.0 | 0.0
```

See below (*) for some more alternate syntaxes and an explanation of how this works.

- added additional, less error-prone syntax for stack:

```
>>> nat = Axis('nat', 'BE,FO')
>>> arr1 = ones(nat)
>>> arr1
nat |  BE |  FO
    | 1.0 | 1.0
>>> arr2 = zeros(nat)
>>> arr2
nat |  BE |  FO
    | 0.0 | 0.0
>>> stack([('M', arr1), ('F', arr2)], 'sex')
nat\sex |   H |   F
     BE | 1.0 | 0.0
     FO | 1.0 | 0.0
```

in addition to the still supported but discouraged (because one has to remember the order of labels):

```
>>> sex = Axis('sex', ['M', 'F'])
>>> stack((arr1, arr2), sex)
nat\sex |   H |   F
     BE | 1.0 | 0.0
     FO | 1.0 | 0.0
```

- added LArray.compact and Session.compact() to detect and remove "useless" axes (ie axes for which values are constant over the whole axis)

```
>>> a = LArray([[1, 2], [1, 2]], [Axis('sex', 'M,F'), Axis('nat', 'BE,FO')])
>>> a
sex\nat | BE | FO
      M |  1 |  2
      F |  1 |  2
>>> a.compact()
nat | BE | FO
    |  1 |  2
```

- made Session keep the order in which arrays were added to it. The main goal was to make this work:

```
>>> b, a = s['b', 'a']
```

Previously, since sessions were always traversed alphabetically, this was a dangerous operation because if the keys (a and b) were not sorted alphabetically, the result would not be in the expected order:

s['b', 'a'] previously returned a, b instead of b, a !!

Session.names is still sorted alphabetically though (Session.keys() is not)

- added LArray.with_axes(axes) to return a new LArray with the same data but different axes

```
>>> a = ndrange(2)
>>> a
{0}* | 0 | 1
     | 0 | 1
>>> a.with_axes([Axis('sex', 'H,F')])
sex | H | F
    | 0 | 1
```

- changed width from which an LArray is summarized (using "...") from 80 characters to 200.
- implemented memory_used property which displays nbytes in human-readable form

```
>>> a = ndrange('sex=H,F;nat=BE,FO')
>>> a.memory_used
'16 bytes'
>>> a = ndrange(100000)
>>> a.memory_used
'390.62 Kb'
```

- implemented Axis + AxisCollection

```
>>> a = ndrange('sex=M,F;type=t1,t2')
>>> Axis('nat', 'BE,FO') + a.axes
AxisCollection([
    Axis('nat', ['BE', 'FO']),
    Axis('sex', ['M', 'F']),
    Axis('type', ['t1', 't2'])
])
```

(*) For the curious, there are also many syntaxes supported for array creation functions. In fact, during array creation, at any place a list or tuple of values is expected, you can specify it using a single string, which will be split successively at the following characters if present: ";" then "=" then ",". If you apply that algorithm to 'nat=BE,FO;sex=M,F', you get:

1) 'nat=BE,FO;sex=M,F'
2) ('nat=BE,FO', 'sex=M,F')
3) (('nat', 'BE,FO'), ('sex', 'M,F'))
4) (('nat', ('BE', 'FO')), ('sex', ('M', 'F')))

Recognise this last syntax? This is the same as above, except above we replaced some () with [] for clarity. In fact all the intermediate forms here above are valid (and equivalent) in array creation functions.

6.1.22 Version 0.15

Released on 2016-09-23.

- added new methods on axes: matches, startswith, endswith

```
>>> country = Axis('country', ['FR', 'BE', 'DE', 'BR'])
>>> country.matches('BE|FR')
LGroup(['FR', 'BE'])
>>> country.matches('^..$') # labels 2 characters long
LGroup(['FR', 'BE', 'DE', 'BR'])
```

```
>>> country.startswith('B')
LGroup(['BE', 'BR'])
>>> country.endswith('R')
LGroup(['FR', 'BR'])
```

- implemented set-like operations on LGroup: & (intersection), | (union), - (difference). Slice groups do not work yet on axes references (x.) but that will come in the future…

```
>>> alpha = Axis('alpha', 'a,b,c,d')
>>> alpha['a', 'b'] | alpha['c', 'd']
LGroup(['a', 'b', 'c', 'd'], axis=...)
>>> alpha['a', 'b', 'c'] | alpha['c', 'd']
LGroup(['a', 'b', 'c', 'd'], axis=...)
```

a name is computed automatically when both operands are named

```
>>> r = alpha['a', 'b'].named('ab') | alpha['c', 'd'].named('cd')
>>> r.name
'ab | cd'
>>> r.key
['a', 'b', 'c', 'd']
```

numeric axes work too

```
>>> num = Axis('num', range(10))
>>> num[:2] | num[8:]
num[0, 1, 2, 8, 9]
>>> num[:2] | num[5]
num[0, 1, 2, 5])
```

intersection

```
>>> LGroup(['a', 'b', 'c']) & LGroup(['c', 'd'])
LGroup(['c'])
```

difference

```
>>> LGroup(['a', 'b', 'c']) - LGroup(['c', 'd'])
LGroup(['a', 'b'])
>>> LGroup(['a', 'b', 'c']) - 'b'
LGroup(['a', 'c'])
```

- fixed loading 1D arrays using open_excel
- added tooltip with the axes labels corresponding to each cell of the array viewer
- added name and dimensions of the current array to the window title bar in the session viewer
- added tooltip with each array .info() in the list of arrays of the session viewer
- fixed eval box throwing an exception when trying to set a new variable (if qtconsole is not present)
- fixed group aggregates using LGroups defined using axes references (x.), for example:

```
>>> arr.sum(x.age[:10])
```

- fixed group aggregates using anonymous axes

6.1.23 Version 0.14.1

Released on 2016-08-12.

- fixed support for loading arrays without axe names from Excel files (in that case index_col/nb_index are necessary)
- fixed using a single int for index_col in read_excel() and sheet.load()
- fixed loading empty Excel sheets via xlwings correctly (ie do not crash)
- fixed dumping a session loaded from an H5 file to Excel

6.1.24 Version 0.14

Released on 2016-08-10.

This version is not compatible with the new version of xlwings that just came out. Consequently, upgrading to this version is different from the usual "conda update larray". You should rather use:

conda update larray –no-update-deps

To get the most of this release, you should also install the "qtconsole" package via:

conda install qtconsole

- upgraded session viewer/editor to work like a super-calculator. The input box below the array view can be used to type any expression. eg array1.sum(x.age) / array2, which will be displayed in the viewer. One can also type assignment commands, like: array3 = array1.sum(x.age) / array2 In which case, the new array will be displayed in the viewer AND added to the session (appear on the list on the left), so that you can use it in other expressions.

  If you have the "qtconsole" package installed (see above), that input box will be a full ipython console. This means:

    - history of typed commands,
    - tab-completion (for example, type "nd<tab>" and it will change to "ndrange"),
    - syntax highlighting,
    - calltips (show the documentation of functions when typing commands using them),
    - help on functions using "?". For example, type "ndrange?<enter>" to get the full documentation about ndrange. Use <ESC> or <q> to quit that screen !),
    - etc.

  When having the "qtconsole" package installed, you might get a warning when starting the viewer:

  ```
  WARNING:root:Message signing is disabled.  This is insecure and not recommended!
  ```

  This is totally harmless and can be safely ignored !

- made view() and edit() without argument equivalent to view(local_arrays()) and edit(local_arrays()) respectively.
- made the viewer on large arrays start a lot faster by using a small subset of the array to guess the number of decimals to display and whether or not to use scientific notation.
- **improved compare():**
    - added support for comparing sessions. Arrays with differences between sessions are colored in red.
    - use a single array widget instead of 3. This is done by stacking arrays together to create a new dimension. This has the following advantages:

        * the filter and scrollbars are de-facto automatically synchronized.
        * any number of arrays can be compared, not just 2. All arrays are compared to the first one.
        * arrays with different sets of compatible axes can be compared (eg compare an array with its mean along an axis).
    - added label to show maximum absolute difference.

- implemented edit(session) in addition to view(session).
- added support for copying sheets via: wb['x'] = wb['y'] if 'x' sheet already existed, it is completely overwritten.
- improved performance. My test models run about 10% faster than with 0.13.
- made cumsum and cumprod aggregate on the last axis by default so that the axis does not need to be specified when there is only one.
- implemented much better support for operations using arrays of different types. For example,
    - fixed create_sequential when mult, inc and initial are of different types eg create_sequential(. . . , initial=1, inc=0.1) had an unexpected integer result because it always used the type of the initial value for the output
    - when appending a string label to an integer axis (eg adding total to an age axis by using with_total()), the resulting axis should have a mixed type, and not be suddenly all string.
    - stack() now supports arrays with different types.
- made stack support arrays with different axes (the result has the union of all axes)
- use xlwings (ie live Excel instance) by default for all Excel input/output, including read_excel(), session.dump and session.load/Session(filename). This has the advantage of more coherent results among the different ways to load/save data to Excel and that simple sessions correctly survive a round-trip to an .xlsx workbook (ie (named) axes are detected properly). However, given the very different library involved, we loose most options that read_excel used to provide (courtesy of pandas.read_excel) and some bugs were probably introduced in the conversion.
- fixed creating a new file via open_excel()
- fixed loading 1D arrays (ranges with height 1 or width 1) via open_excel()
- fixed sheet['A1'] = array in some cases
- wb.close() only really close if the workbook was not already open in Excel when open_excel was called (so that we do not close a workbook a user is actually viewing).
- added support for wb.save(filename), or actually for using any relative path, instead of a full absolute path.
- when dumping a session to Excel, sort sheets alphabetically instead of dumping them in a "random" order.
- try to convert float to int in more situations
- added support for using stack() without providing an axis. It creates an anonymous wildcard axis of the correct length.
- added aslarray() top-level function to translate anything into an LArray if it is not already one
- made labels_array available via *from larray import **
- fixed binary operations between an array and an axis where the array appeared first (eg array > axis). Confusingly, axis < array already worked.
- added check in "a[bool_larray_key]" to make sure key.axes are compatible with a.axes
- made create_sequential a lot faster when mult or inc are constants
- made axes without name compatible with any name (this is the equivalent of a wildcard name for labels)

- misc cleanup/docstring improvements/improved tests/improved error messages

6.1.25 Version 0.13

Released on 2016-07-11.

- implemented a new way to do input/output from/to Excel

```
>>> a = ndrange((2, 3))
>>> wb = open_excel('c:/tmp/y.xlsx')
# put a at A1 in Sheet1, excluding headers (labels)
>>> wb['Sheet1'] = a
# dump a at A1 in Sheet2, including headers (labels)
>>> wb['Sheet2'] = a.dump()
# save the file to disk
>>> wb.save()
# close it
>>> wb.close()
```

```
>>> wb = open_excel('c:/tmp/y.xlsx')
# load a from the data starting at A1 in Sheet1, assuming the absence of headers.
>>> a1 = wb['Sheet1']
# load a from the data starting at A1 in Sheet1, assuming the presence of␣
↪(correctly formatted) headers.
>>> a2 = wb['Sheet2'].load()
>>> wb.close()
```

```
>>> wb = open_excel('c:/tmp/y.xlsx')
# note that Sheet2 must exist
>>> sheet2 = wb['Sheet2']
# write a without labels starting at C5
>>> sheet2['C5'] = a
# write a with its labels starting at A10
>>> sheet2['A10'] = a.dump()
```

load an array with its axes information from a range. As you might have guessed, we could also use the sheet2 variable here

```
>>> b = wb['Sheet2']['A10:D12'].load()
>>> b
{0}*\{1}* | 0 | 1 | 2
        0 | 0 | 1 | 2
        1 | 3 | 4 | 5
```

load an array (raw data) with no axis information from a range.

```
>>> c = sheet['B11:D12']
>>> # in fact, this is not really an LArray ...
>>> c
<larray.excel.Range at 0x1ff1bae22e8>
>>> # but it can be used as such (this is currently very experimental)
>>> c.sum(axis=0)
{0}* |   0 |   1 |   2
     | 3.0 | 5.0 | 7.0
>>> # ... and it can be used for other stuff, like setting the formula instead of␣
↪the value:
```

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```
>>> c.formula = '=D10+1'
>>> # in the future, we should also be able to set font name, size, style, etc.
```

- implemented LArray.rename({axis: new_name}) as well as using kwargs to rename several axes at once

```
>>> nat = Axis('nat', ['BE', 'FO'])
>>> sex = Axis('sex', ['M', 'F'])
>>> a = ndrange([nat, sex])
>>> a
nat\sex | M | F
     BE | 0 | 1
     FO | 2 | 3
>>> a.rename(nat='nat2', sex='gender')
nat2\gender | M | F
         BE | 0 | 1
         FO | 2 | 3
>>> a.rename({'nat': 'nat2', 'sex': 'gender'})
nat2\gender | M | F
         BE | 0 | 1
         FO | 2 | 3
```

- made tab-completion of axes names possible in an interactive console
- taking a subset of an array with wildcard axes now returns an array with wildcard axes
- fixed a case where wildcard axes were considered incompatible when they actually were compatible
- better support for anonymous axes
- fix for obscure bugs, better doctests, cleaner implementation for a few functions, . . .

6.1.26 Version 0.12

Released on 2016-06-21.

- implemented boolean indexing by using axes objects:

```
>>> sex = Axis('sex', 'M,F')
>>> age = Axis('age', range(5))
>>> a = ndrange((sex, age))
>>> a
sex\age | 0 | 1 | 2 | 3 | 4
      M | 0 | 1 | 2 | 3 | 4
      F | 5 | 6 | 7 | 8 | 9
```

```
>>> a[age < 3]
sex\age | 0 | 1 | 2
      M | 0 | 1 | 2
      F | 5 | 6 | 7
```

This new syntax is equivalent to (but currently much slower than):

```
>>> a[age[:2]]
sex\age | 0 | 1 | 2
      M | 0 | 1 | 2
      F | 5 | 6 | 7
```

However, the power of this new syntax comes from the fact that you are not limited to scalar constants

```
>>> age_limit = LArray([2, 3], sex)
>>> age_limit
sex | M | F
    | 2 | 3
```

```
>>> a[age < age_limit]
sex,age | M,0 | M,1 | F,0 | F,1 | F,2
        |   0 |   1 |   5 |   6 |   7
```

Notice that the concerned axes are merged, so you cannot do much as much with them. For example, *a[age < age_limit].sum(x.age)* would not work since there is no "age" axis anymore.

To keep axes intact, one can often set the values of the corresponding cells to 0 or nan instead.

```
>>> a[age < age_limit] = 0
>>> a
sex\age | 0 | 1 | 2 | 3 | 4
      M | 0 | 0 | 2 | 3 | 4
      F | 0 | 0 | 0 | 8 | 9
>>> # in this case, the sum *is* valid (but the mean would not -- one should use␣
↪nan for that)
>>> a.sum(x.age)
sex | M |  F
    | 9 | 17
```

To keep axes intact, this idiom is also often useful:

```
>>> b = a * (age >= age_limit)
>>> b
sex\age | 0 | 1 | 2 | 3 | 4
      M | 0 | 0 | 2 | 3 | 4
      F | 0 | 0 | 0 | 8 | 9
```

This also works with axes references (x.axis_name), though this is experimental and the filter value is only computed as late as possible (during []), so you cannot display it before that, like you can with "real" axes.

Using "real" axes:

```
>>> filter1 = age < age_limit
>>> filter1
age\sex |     M |     F
      0 |  True |  True
      1 |  True |  True
      2 | False |  True
      3 | False | False
      4 | False | False
>>> a[filter1]
sex,age | M,0 | M,1 | F,0 | F,1 | F,2
        |   0 |   1 |   5 |   6 |   7
```

With axes references:

```
>>> filter2 = x.age < age_limit
>>> filter2
<larray.core.BinaryOp at 0x1332ae3b588>
>>> a[filter2]
```

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```
sex,age | M,0 | M,1 | F,0 | F,1 | F,2
        |   0 |   1 |   5 |   6 |   7
>>> a * ~filter2
sex\age | 0 | 1 | 2 | 3 | 4
      M | 0 | 0 | 2 | 3 | 4
      F | 0 | 0 | 0 | 8 | 9
```

- implemented LArray.divnot0

```
>>> nat = Axis('nat', ['BE', 'FO'])
>>> sex = Axis('sex', ['M', 'F'])
>>> a = ndrange((nat, sex))
>>> a
nat\sex | M | F
     BE | 0 | 1
     FO | 2 | 3
>>> b = ndrange(sex)
>>> b
sex | M | F
    | 0 | 1
>>> a / b
nat\sex |   M |   F
     BE | nan | 1.0
     FO | inf | 3.0
>>> a.divnot0(b)
nat\sex |   M |   F
     BE | 0.0 | 1.0
     FO | 0.0 | 3.0
```

- implemented .named() on groups to name groups after the fact

```
>>> a = ndrange(Axis('age', range(100)))
>>> a
age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | ... | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99
    | 0 | 1 | 2 | 3 | 4 | 5 | 6 | ... | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99
>>> a.sum((x.age[10:19].named('teens'), x.age[20:29].named('twenties')))
age | 'teens' (10:19) | 'twenties' (20:29)
    |             145 |                245
```

- made all array creation functions (ndrange, zeros, ones, full, LArray, …) more flexible:

  They accept a single Axis argument instead of requiring a tuple/list of them

```
>>> sex = Axis('sex', 'M,F')
>>> a = ndrange(sex)
>>> a
sex | M | F
    | 0 | 1
```

  Shortcut definition for axes work

```
>>> ndrange("a,b,c")
{0} | a | b | c
    | 0 | 1 | 2
>>> ndrange(["1:3", "d,e"])
{0}\{1} | d | e
      1 | 0 | 1
```

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```
      2 | 2 | 3
      3 | 4 | 5
>>> LArray([1, 5, 7], "a,b,c")
{0} | a | b | c
    | 1 | 5 | 7
```

One can mix Axis objects and ints (for axes without labels)

```
>>> sex = Axis('sex', 'M,F')
>>> ndrange([sex, 3])
sex\{1}* | 0 | 1 | 2
       M | 0 | 1 | 2
       F | 3 | 4 | 5
```

- made it possible to iterate on labels of a group (eg a slice of an Axis):

```
>>> for year in a.axes.year[2010:]:
...     # do stuff
```

- changed representation of anonymous axes from “axisN” (where N is the position of the axis) to “{N}”. The problem was that “axisN” was not recognizable enough as an anonymous axis, and it was thus misleading. For example “a[x.axis0[. . .]]” would not work.
- better overall support for arrays with anonymous axes or several axes with the same name
- fixed all output functions (to_csv, to_excel, to_hdf, . . .) when the last axis has no name but other axes have one
- implemented eye() which creates 2D arrays with ones on the diagonal and zeros elsewhere.

```
>>> eye(sex)
sex\sex |   M |   F
      M | 1.0 | 0.0
      F | 0.0 | 1.0
```

- implemented the @ operator to do matrix multiplication (Python3.5+ only)
- implemented inverse() to return the (matrix) inverse of a (square) 2D array

```
>>> a = eye(sex) * 2
>>> a
sex\sex |   M |   F
      M | 2.0 | 0.0
      F | 0.0 | 2.0
```

```
>>> a @ inverse(a)
sex\sex |   M |   F
      M | 1.0 | 0.0
      F | 0.0 | 1.0
```

- implemented diag() to extract a diagonal or construct a diagonal array.

```
>>> nat = Axis('nat', ['BE', 'FO'])
>>> sex = Axis('sex', ['M', 'F'])
>>> a = ndrange([nat, sex], start=1)
>>> a
nat\sex | M | F
     BE | 1 | 2
```

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```
     FO | 3 | 4
>>> d = diag(a)
>>> d
nat,sex | BE,M | FO,F
        |    1 |    4
>>> diag(d)
nat\sex | M | F
     BE | 1 | 0
     FO | 0 | 4
>>> a = ndrange(sex, start=1)
>>> a
sex | M | F
    | 1 | 2
>>> diag(a)
sex\sex | M | F
      M | 1 | 0
      F | 0 | 2
```

- added Axis.rename method which returns a copy of the axis with a different name and deprecate Axis._rename
- added labels_array as a generalized version of identity (which is deprecated)
- implemented LArray.ipoints[...] to do point selection using coordinates instead of labels (aka numpy indexing)
- raise an error when trying to do a[key_with_more_axes_than_a] = value instead of silently ignoring extra axes.
- allow using a single int for index_col in read_csv in addition to a list of ints
- implemented __getitem__ for "x". You can now write stuff like:

```
>>> a = ndrange((3, 4))
>>> a[x[0][1:]]
{0}\{1}* | 0 | 1 |  2 |  3
       1 | 4 | 5 |  6 |  7
       2 | 8 | 9 | 10 | 11
>>> a[x[1][2:]]
{0}*\{1} |  2 |  3
       0 |  2 |  3
       1 |  6 |  7
       2 | 10 | 11
>>> a.sum(x[0])
{0}* |  0 |  1 |  2 |  3
     | 12 | 15 | 18 | 21
```

- produce normal axes instead of wildcard axes on LArray.points[...]. This is (much) slower but more correct/informative.
- changed the way we store axes internally, which has several consequences
  - better overall support for anonymous axes
  - better support for arrays with several axes with the same name
  - small performance improvement
  - the same axis object cannot be added twice in an array (one should use axis.copy() if that need arises)
  - changes the way groups with an axis are displayed
- fixed sum, min, max functions on non-LArray arguments
- changed __repr__ for wildcard axes to not display their labels but their length

```
>>> ndrange(3).axes[0]
Axis(None, 3)
```

- fixed aggregates on several groups "forgetting" the name of groups which had been created using axis.all()
- allow Axis(. . . , long) in addition to int (Python2 only)
- better docstrings/tests/comments/error messages/thoughts/. . .

6.1.27 Version 0.11.1

Released on 2016-05-25.

- fixed new functions full, full_like and create_sequential not being available when using *from larray import **

6.1.28 Version 0.11

Released on 2016-05-25.

- implemented "Copy to Excel" in context menu (Ctrl+E), to open the selection in a new Excel sheet directly, without the need to use paste. If nothing is selected, copies the whole array.
- when nothing is selected, Ctrl C selects & copies the whole array to the clipboard.
- when nothing is selected, Ctrl V paste at top-left corner
- implemented view(dict_with_array_values)

```
>>> view({'a': array1, 'b': array2})
```

- fixed copy (ctrl-C) when viewing a 2D array: it did not include labels from the first axis in that case
- implemented LArray.growth_rate to compute the growth along an axis

```
>>> sex = Axis('sex', ['M', 'F'])
>>> year = Axis('year', [2015, 2016, 2017])
>>> a = ndrange([sex, year]).cumsum(x.year)
>>> a
sex\year | 2015 | 2016 | 2017
       M |    0 |    1 |    3
       F |    3 |    7 |   12
>>> a.growth_rate()
sex\year |          2016 |           2017
       M |           inf |            2.0
       F | 1.33333333333 | 0.714285714286
>>> a.growth_rate(d=2)
sex\year | 2017
       M |  inf
       F |  3.0
```

- implemented LArray.diff (difference along an axis)

```
>>> sex = Axis('sex', ['M', 'F'])
>>> xtype = Axis('type', ['type1', 'type2', 'type3'])
>>> a = ndrange([sex, xtype]).cumsum(x.type)
>>> a
sex\type | type1 | type2 | type3
```

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```
       M |      0 |      1 |      3
       F |      3 |      7 |     12
>>> a.diff()
sex\type | type2 | type3
       M |      1 |      2
       F |      4 |      5
>>> a.diff(n=2)
sex\type | type3
       M |      1
       F |      1
>>> a.diff(x.sex)
sex\type | type1 | type2 | type3
       F |      3 |      6 |      9
```

- implemented round() (as a nicer alias to around() and round_())

```
>>> a = ndrange(5) + 0.5
>>> a
axis0 |   0 |   1 |   2 |   3 |   4
      | 0.5 | 1.5 | 2.5 | 3.5 | 4.5
>>> round(a)
axis0 |   0 |   1 |   2 |   3 |   4
      | 0.0 | 2.0 | 2.0 | 4.0 | 4.0
```

- implemented Session[['list', 'of', 'str']] to get a subset of a Session

```
>>> s = Session({'a': ndrange(3), 'b': ndrange(4), 'c': ndrange(5)})
>>> s
Session(a, b, c)
>>> s['a', 'c']
Session(a, c)
```

- implemented LArray.points to do pointwise indexing instead of the default orthogonal indexing when indexing several dimensions at the same time.

```
>>> a = Axis('a', ['a1', 'a2', 'a3'])
>>> b = Axis('b', ['b1', 'b2', 'b3'])
>>> arr = ndrange((a, b))
>>> arr
a\b | b1 | b2 | b3
a1 |  0 |  1 |  2
a2 |  3 |  4 |  5
>>> arr[['a1', 'a3'], ['b1', 'b2']]
a\b | b1 | b2
a1 |  0 |  1
a3 |  6 |  7
# this selects the points ('a1', 'b1') and ('a3', 'b2')
>>> arr.points[['a1', 'a3'], ['b1', 'b2']]
a,b* | 0 | 1
     | 0 | 7
```

Note that .ipoints (to do pointwise indexing with positions instead of labels – aka numpy indexing) is planned but not functional yet.

- made "arr1.drop_labels() * arr2" use the labels from arr2 if any

```
>>> a = Axis('a', ['a1', 'a2'])
>>> b = Axis('b', ['b1', 'b2'])
>>> b2 = Axis('b', ['b2', 'b3'])
>>> arr1 = ndrange([a, b])
>>> arr1
a\b | b1 | b2
a1 |  0 |  1
a2 |  2 |  3
>>> arr1.drop_labels(b)
a\b* | 0 | 1
  a1 | 0 | 1
  a2 | 2 | 3
>>> arr1.drop_labels([a, b])
a*\b* | 0 | 1
    0 | 0 | 1
    1 | 2 | 3
>>> arr2 = ndrange([a, b2])
>>> arr2
a\b | b2 | b3
a1 |  0 |  1
a2 |  2 |  3
>>> arr1 * arr2
Traceback (most recent call last):
...
ValueError: incompatible axes:
Axis('b', ['b2', 'b3'])
vs
Axis('b', ['b1', 'b2'])
>>> arr1 * arr2.drop_labels()
a\b | b1 | b2
a1 |  0 |  1
a2 |  4 |  9
# in versions < 0.11, it used to return:
# >>> arr1.drop_labels() * arr2
# a*\b* | 0 | 1
#     0 | 0 | 1
#     1 | 2 | 3
>>> arr1.drop_labels() * arr2
a\b | b2 | b3
a1 |  0 |  1
a2 |  4 |  9
>>> arr1.drop_labels('a') * arr2.drop_labels('b')
a\b | b1 | b2
a1 |  0 |  1
a2 |  4 |  9
```

- made .plot a property, like in Pandas, so that we can do stuff like:

```
>>> a.plot.bar()
# instead of
>>> a.plot(kind='bar')
```

- made labels from different types not match against each other even if their value is the same. This might break some code but it is both more efficient and more convenient in some cases, so let us see how it goes:

```
>>> a = ndrange(4)
>>> a
```

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```
axis0 | 0 | 1 | 2 | 3
      | 0 | 1 | 2 | 3
>>> a[1]
1
>>> # This used to "work" (and return 1)
>>> a[True]
...
ValueError: True is not a valid label for any axis
```

```
>>> a[1.0]
...
ValueError: 1.0 is not a valid label for any axis
```

- implemented read_csv(dialect='liam2') to read .csv files formatted like in LIAM2 (with the axes names on a separate line than the last axis labels)
- implemented Session[boolean LArray]

```
>>> a = ndrange(3)
>>> b = ndrange(4)
>>> s1 = Session({'a': a, 'b': b})
>>> s2 = Session({'a': a + 1, 'b': b})
>>> s1 == s2
name |     a |    b
     | False | True
>>> s1[s1 == s2]
Session(b)
>>> s1[s1 != s2]
Session(a)
```

- implemented experimental support for creating an array sequentially. Comments on the name of the function and syntax (especially compared to ndrange) would be appreciated.

```
>>> year = Axis('year', range(2016, 2020))
>>> sex = Axis('sex', ['M', 'F'])
>>> create_sequential(year)
year | 2016 | 2017 | 2018 | 2019
     |    0 |    1 |    2 |    3
>>> create_sequential(year, 1.0, 0.1)
year | 2016 | 2017 | 2018 | 2019
     |  1.0 |  1.1 |  1.2 |  1.3
>>> create_sequential(year, 1.0, mult=1.1)
year | 2016 | 2017 | 2018 |  2019
     |  1.0 |  1.1 | 1.21 | 1.331
>>> inc = LArray([1, 2], [sex])
>>> inc
sex | M | F
    | 1 | 2
>>> create_sequential(year, 1.0, inc)
sex\year | 2016 | 2017 | 2018 | 2019
       M |  1.0 |  2.0 |  3.0 |  4.0
       F |  1.0 |  3.0 |  5.0 |  7.0
>>> mult = LArray([2, 3], [sex])
>>> mult
sex | M | F
    | 2 | 3
```

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```
>>> create_sequential(year, 1.0, mult=mult)
sex\year | 2016 | 2017 | 2018 | 2019
       M |  1.0 |  2.0 |  4.0 |  8.0
       F |  1.0 |  3.0 |  9.0 | 27.0
>>> initial = LArray([3, 4], [sex])
>>> initial
sex | M | F
    | 3 | 4
>>> create_sequential(year, initial, inc, mult)
sex\year | 2016 | 2017 | 2018 | 2019
       M |    3 |    7 |   15 |   31
       F |    4 |   14 |   44 |  134
>>> def modify(prev_value):
...     return prev_value / 2
>>> create_sequential(year, 8, func=modify)
year | 2016 | 2017 | 2018 | 2019
     |    8 |    4 |    2 |    1
>>> create_sequential(3)
axis0* | 0 | 1 | 2
       | 0 | 1 | 2
>>> create_sequential(x.year, axes=(sex, year))
sex\year | 2016 | 2017 | 2018 | 2019
       M |    0 |    1 |    2 |    3
       F |    0 |    1 |    2 |    3
```

- implemented full and full_like to create arrays initialize to something else than zeros or ones

```
>>> nat = Axis('nat', ['BE', 'FO'])
>>> sex = Axis('sex', ['M', 'F'])
>>> full([nat, sex], 42.0)
nat\sex |    M |    F
     BE | 42.0 | 42.0
     FO | 42.0 | 42.0
>>> initial_value = ndrange([sex])
>>> initial_value
sex | M | F
    | 0 | 1
>>> full([nat, sex], initial_value)
nat\sex | M | F
     BE | 0 | 1
     FO | 0 | 1
```

- performance improvements when using label keys: a[key] is faster, especially if key is large
- to_excel(filepath) only closes the file if it was not open before
- removed code which forced labels from .csv files to be strings (as it caused problems in many cases, e.g. ages in LIAM2 files)
- made LGroups usable in Python's builtin range() and convertible to int and float
- implemented AxisCollection.union (equivalent to AxisCollection | Axis)
- fixed boolean array keys (boolean filter) in combination with scalar keys (for other dimensions)
- fixed support for older numpy
- fixed LArray.shift(n=0)
- still more work on making arrays with anonymous axes usable (not there yet)

- added more tests
- better docstrings/error messages…
- misc. code cleanup/simplification/improved comments

6.1.29 Version 0.10.1

Released on 2016-03-25.

- A single change in this release: a much more powerful to_excel function which (by default) use Excel itself to write files. Additional functionality include:
  - write in an existing file without overwriting existing data/sheet/…
  - write at a precise position
  - view an array in a live Excel instance (a new OR an existing workbook)

  See `to_excel()` documentation for details.

6.1.30 Version 0.10

Released on 2016-03-22.

- implemented dropna argument for to_csv, to_frame and to_series to avoid writing lines with either 'all' or 'any' NA values.
- implemented read_sas. Needs pandas >= 0.18 (though it seems still buggy on some files).
- implemented experimental support for __getattr__ and __setattr__ on LArray. One can use arr.H instead of arr['M']. It only works for single string labels though (not for slices or list of labels nor integer labels). Not sure it is a good idea :).
- **implemented Session +-*/** Eg. sess1 - sess2 will compute the difference on each array present in either session.
  If an array is present in one session and not in the other, it is replaced by "NaN".
- added .nbytes property to LArray objects (to know how many bytes of memory the array uses)
- made sort_axis accept a tuple of axes
- raises an error on a.i[tuple_with_len_greater_than_array_ndim]
- slightly better support for axes with no name (no, still no complete support yet ;-))
- improved AxisCollection: implemented __delitem__(slice), __setitem__(list), __setitem__(slice)
- fixed exception on AxisCollection.index(invalid_index)
- better docstrings for a few functions
- misc code cleanups, refactoring & improved tests
- added .dirty property on ArrayEditorWidget
- fixed viewing arrays with "inf" (infinite)
- fixed a few edge cases for the ndigit detection code
- fixed colors in some cases in edit()
- made copy-paste of large regions faster in some cases

6.1.31 Version 0.9.2

Released on 2016-03-02.

- much better support for unnamed axes overall. Still a long way to go for full support, but it's getting there…
- fixed edit() for arrays with the same labels on several axes

6.1.32 Version 0.9.1

Released on 2016-03-01.

- better .info for arrays with groups in axes

```
>>> # example using groups without a name
>>> reg = la.sum((fla, wal, bru, belgium))
>>> reg.info
4 x 15
 geo [4]: ['A11' ... 'A73'] ['A25' ... 'A93'] 'A21' ['A11' ... 'A21']
 lipro [15]: 'P01' 'P02' 'P03' ... 'P13' 'P14' 'P15'
```

```
>>> # example using groups with a name
>>> fla = geo.group(fla_str, name='Flanders')
>>> wal = geo.group(wal_str, name='Wallonia')
>>> bru = geo.group(bru_str, name='Brussels')
>>> reg = la.sum((fla, wal, bru))
>>> reg.info
3 x 15
 geo [3]: 'Flanders' (['A11' ... 'A73']) 'Wallonia' (['A25' ... 'A93']) 'Brussels
↪' ('A21')
 lipro [15]: 'P01' 'P02' 'P03' ... 'P13' 'P14' 'P15'
```

- fixed edit() with non-string labels in axes
- fixed edit() with filters in some more cases
- fixed ArrayEditorWidget.reject_changes and accept_changes to update the model & view accordingly (in case the widget is kept open)
- avoid (harmless) error messages in some cases

6.1.33 Version 0.9

Released on 2016-02-25.

A minor but backward incompatible version (hence the bump in version number)!

- fixed int_array.mean() to return floats instead of int (regression in 0.8)
- larray_equal returns False when either value is not an LArray, instead of raising an exception
- changed *Session* == *Session* to return an array of booleans instead of a single boolean, so that we know which array(s) differ. Code like *session1* == *session2*, should be changed to *all(session1* == *session2)*.
- implemented Session != Session
- implemented Session.get(k, default) (returns default if k does not exist in Session)
- implemented len() for Session objects to know how many objects are in the Session

- fixed view() (regression in 0.8.1)
- fixed edit() to actually apply changes on "OK"/accept_changes even when no filter change occurred after the last edit.

6.1.34 Version 0.8.1

Released on 2016-02-24.

- implemented min/maxvalue arguments for edit()
- do not close the window when pressing Enter
- allow to start editing cells by pressing Enter
- fixed copy of changed cells (copy the changed value)
- fixed pasted values to not be accepted directly (they go to "changes" like for manual edits)
- fixed color updates on paste
- disabled experimental tooltips on headers
- better error message when entering invalid values
- implemented indexing by position on several dimensions at once (like numpy)

```
>>> # takes the first item in the first and third dimensions, leave the second␣
↪dimension intact
>>> arr.i[0, :, 0]
<some result>
>>> # sets all the cells corresponding to the first item in the first dimension␣
↪and the second item in the fourth
>>> # dimension
>>> arr.i[0, :, :, 1] = 42
```

- added optional 'readonly' argument to expand() to produce a readonly view (much faster since no copying is done)

6.1.35 Version 0.8

Released on 2016-02-16.

- implemented skipna argument for most aggregate functions. defaults to True.
- implemented LArray.sort_values(key)
- implemented percentile and median
- added isnan and isinf toplevel functions
- made axis argument optional for argsort & posargsort on 1D arrays
- fixed a[key] = value when key corresponds to a single cell of the array
- fixed keepaxes argument for aggregate functions
- fixed a[int_array] (when the axis needs to be guessed)
- fixed empty_like
- fixed aggregates on several axes given as integers e.g. arr.sum(axis=(0, 2))
- fixed "kind" argument in posargsort

- added title argument to edit() (set automatically if not provided, like for view())
- fixed edit() on filtered arrays
- fixed view(expression). anything which was not stored in a variable was broken in 0.7.1
- reset background color when setting values if necessary (still buggy in some cases, but much less so ;-))
- background color for headers is always on
- view() => array cells are not editable, instead of being editable and ignoring entered values
- fixed compare() colors when arrays are entirely equal
- fixed error message for compare() when PyQt is not available
- bump numpy requirement to 1.10, implicitly dropping support for python 3.3
- renamed view module to editor to not collide with view function
- improved/added a few tests

6.1.36 Version 0.7.1

Released on 2016-01-29.

- implemented paste (ctrl-V)
- implemented experimental array comparator:

  ```
  >>> compare(array1, array2)
  ```

  Known limitation: the arrays must have exactly the same axes and the background color is buggy when using filters
- when no title is specified in view(), it is determined automatically by inspecting the local variables of the function where view() is called and using the names of the ones matching the object passed. If several matches, up to 3 are displayed.
- added axes names to copy (ctrl-C)
- fixed copy (ctrl-C) of 0d array
- added 'dialect' argument to to_csv. For example, dialect='classic' does not include the last (horizontal) axis name.
- fixed loading .csv files without (ie 'classic' .csv files), though one needs to specify nb_index in that case if ndim > 2
- strip spaces around axes names so that you can use "axis0<space><space>axis1" instead of "axis0axis1" in .csv files
- fixed 1d arrays I/O
- more precise parsing of input headers: 1 and 0 come out as int, not bool
- nicer error message when using an invalid axes names
- changed LArray .df property to a to_frame() method so that we can pass options to it

6.1.37 Version 0.7

Released on 2016-01-26.

- implemented view() on Session objects
- added axes length in window title and add axes info even if title is provided manually (concatenate both)
- ndecimals are recomputed when toggling the scientific checkbox
- allow viewing (some) non-ndarray stuff (e.g. python lists)
- refactored viewer code so that the filter drop downs can be reused too
- Known regression: the viewer is slow on large arrays (this will be fixed in a later release, obviously)
- implemented local_arrays() to return all LArray in locals() as a Session
- implemented Session.__getitem__(int_position)
- implement Session(filename) to directly load all arrays from a file. Equivalent to:

```
>>> s = Session()
>>> s.load(filename)
```

- implemented Session.__eq__, so that you can compare two sessions and see if all arrays are equal. Suppose you want to refactor your code and make sure you get the same results.

```
>>> # put results in a Session
>>> res = Session({'array1': array1, 'array2': array2})
>>> # before refactoring
>>> res.dump('results.h5')
>>> # after refactoring
>>> assert Session('results.h5') == res
```

- you can load all sheets/arrays of a file (if you do not specify which ones you want, it takes all)
- loading several sheets from an excel file is now MUCH faster because the same file is kept open (apparently xlrd parses the whole file each time we open it).
- you can specify a subset of arrays to dump
- implemented rudimentary session I/O for .csv files, usage is a bit different from .h5 & excel files

```
>>> # need to specify format manually
>>> s.dump('directory_name', fmt='csv')
>>> # need to specify format manually
>>> s = Session()
>>> s.load('directory_name', fmt='csv')
```

- pass **args* and ***kwargs* to lower level functions in Session.load
- fail when trying to read an inexistant H5 file through Session, instead of creating it
- added start argument in ndrange to specify starting value
- implemented Axis._rename. Not sure it's a good idea though…
- implemented identity function which takes an Axis and returns an LArray with the axis labels as values
- implemented size property on AxisCollection
- allow a single int in AxisCollection.without
- fixed broadcast_with when other_axes contains 0-len axes

- fixed a[bool_array] = value when the first axis of a is not in bool_array
- fixed view() on arrays with unnamed axes
- fixed view() on arrays of Python objects
- various other small bugs fixed

6.1.38 Version 0.6.1

Released on 2016-01-13.

- added dtype argument to all array creation functions to override default data type
- aggregates can take an explicit "axis" keyword argument which can be used to target an axis by index

```
>>> arr.sum(axis=0)
```

- implemented LGroup.__getitem__ & LGroup.__iter__, so that for list-based groups (ie not slices) you can write:

```
>>> for v in my_group:
...     # some code
```

or

```
>>> my_group[0]
```

- renamed LabelGroup to LGroup and PositionalKey to PGroup. We might want to rename the later to IGroup (to be consistent with axis.i[. . .]).
- slightly better support for axes without name
- better docstrings for a few functions
- misc cleanup
- fixed XXX_like(a) functions to use the same dtype than a instead of always float
- fixed to_XXX with 1d arrays (e.g. to_clipboard())
- fixed all() and any() toplevel functions without argument
- fixed LArray without axes in some cases
- fixed array creation functions with only shapes on python2

6.1.39 Version 0.6

Released on 2016-01-12.

- a[bool_array_key] broadcasts missing/differently ordered dimensions and returns an LArray with combined axes
- a[bool_array_key] = value broadcasts missing/differently ordered dimensions on both key and value
- **implemented argmin, argmax, argsort, posargmin, posargmax, posargsort.** they do indirect operation along an axis. E.g. argmin gives the label of the minimum value, argsort gives the labels which would sort the array along that dimension. posargXXX gives the position/indexes instead of the labels.
- implemented Axis.__iter__ so that one can write:

```
>>> for label in an_array.axes.an_axis:
...     <some code>
```

instead of

```
>>> for label in an_array.axes.an_axis.labels:
...     <some code>
```

- implemented the .info property on AxisCollection
- implement all/any top level functions, so that you can use them in with_total.
- renamed ValueGroup to LabelGroup. We might want to rename it to LGroup to be consistent with LArray?
- allow a single int as argument to LArray creation functions (ndrange et al.)

  e.g. *ndrange(10)* is now allowed instead of *ndrange([10])*
- use display_name in .info (ie add * next to wildcard axes in .info).
- allow specifying a custom window title in view()
- viewer displays booleans as True/False instead of 1/0
- slightly better support for axes with no name (None). There is still a long way to go for full support though.
- improved a few docstrings
- nicer errors when tests results are different from expected
- removed debug prints from viewer
- misc cleanups
- fixed view() on all-negative arrays
- fixed view() on string arrays

6.1.40 Version 0.5

Released on 2015-12-15.

- experimental support for indexing an LArray by another (integer) LArray

```
>>> array[other_array]
```

- experimental support for LArray.drop_labels and the concept of wildcard axes
- added LArray.display_name and AxisCollection.display_names which add '*' next to wildcard axes
- implemented where(cond, array1, array2)
- implemented LArray.__iter__ so that this works:

```
>>> for value in array:
...     <some code>
```

- implement keepaxes=label or keepaxes=True for aggregate functions on full axes

  array.sum(x.age, keepaxes='total')
- AxisCollection.replace can replace several axes in one call
- implemented .expand(out=) to expand into an existing array

- removed Axis.sorted()
- removed LArray.axes_names & axes_labels. One should use .axes.names & .axes.labels instead.
- raise an error when trying to convert an array with more than one value to a Boolean. For example, this will fail:

```
>>> arr = ndrange([sex])
>>> if arr:
...     <some code>
```

- convert value to self.dtype in append/prepend
- faster .extend, .append, .prepend and .expand
- some code cleanup, better tests, ...
- fixed .extend when other has longer axes than self

6.1.41 Version 0.4

Released on 2015-12-09.

- implemented LArray.expand to add dimensions
- implemented prepend
- implemented sort_axis
- allow creating 0d (scalar) LArrays
- made extend expand its arguments
- made .append expand its value before appending
- changed read_* to not sort data by default
- more minor stuff :)
- fixed loading 1d arrays

6.1.42 Version 0.3

Released on 2015-11-26.

- implemented LArray.with_total(): appends axes or group aggregates to the array.

  Without argument, it adds totals on all axes. It has optional keyword only arguments:

  – *label*: specify the label ("total" by default)

  – *op*: specify the aggregate function (sum by default, all other aggregates should work too)

  With multiple arguments, it adds totals sequentially. There are some tricky cases. For example when, for the same axis, you add group aggregates and axis aggregates:

```
>>> # works but "wrong" for x.geo (double what is expected because the total also
>>> # includes fla wal & bru)
>>> la.with_total(x.sex, (fla, wal, bru), x.geo, x.lipro)
```

```
>>> # correct total but the order is not very nice
>>> la.with_total(x.sex, x.geo, (fla, wal, bru), x.lipro)
```

```
>>> # the correct way to do it, but it is probably not entirely obvious
>>> la.with_total(x.sex, (fla, wal, bru, x.geo.all()), x.lipro)
```

```
>>> # we probably want to display a warning (or even an error?) in that case.
>>> # If the user really wants that behavior, he can split the operation:
>>> # .with_total((fla, wal, bru)).with_total(x.geo)
```

- implemented group aggregates without using keyword arguments. As a consequence of this, one can no longer use axis numbers in aggregates. Eg. *a.sum(0)* does not sum on the first axis anymore (but you can do *a.sum(a.axes[0])* if needed)
- implemented LArray.percent: equivalent to ratio * 100
- implemented Session.filter -> returns a new Session with only objects matching the filter
- implemented Session.dump -> dumps all LArray in the Session to a file
- implemented Session.load -> load several LArrays from a file to a Session

6.1.43 Version 0.2.6

Released on 2015-11-24.

- fixed LArray.cumsum and cumprod.
- fixed all doctests just enough so that they run.

6.1.44 Version 0.2.5

Released on 2015-10-29.

- many methods got (improved) docstrings (Thanks to Johan).
- fixed mixing keys without axis (e.g. arr[10:15]) with key with axes (e.g. arr[x.age[10:15]]).

6.1.45 Version 0.2.4

Released on 2015-10-27.

- includes an experimental (slightly inefficient) version of guess axis, so that one can write:

  ```
  >>> arr[10:20]
  ```

  instead of

  ```
  >>> arr[age[10:20]]
  ```

6.1.46 Version 0.2.3

Released on 2015-10-19.

- positional slicing via "x." syntax (x.axis.i[:5])
- view(array) is usable when doing *from larray import **
- fixed a nasty bug for doing "group" aggregates when there is only one dimension

6.1.47 Version 0.2.2

Released on 2015-10-15.

- implement AxisCollection.replace(old_axis, new_axis)
- implement positional indexing
- more powerful AxisCollection.pop added support .pop(name) or .pop(Axis object)
- LArray.set_labels returns a new LArray by default use inplace=True to get previous behavior
- include ndrange and __version__ in __all__
- fixed shift with n <= 0

6.1.48 Version 0.2.1

Released on 2015-10-14.

- implemented LArray.shift(axis, n=1)
- change set_labels API (axis, new_labels)
- transform Axis.labels into a property so that _mapping is kept in sync
- hopefully fix build

6.1.49 Version 0.2

Released on 2015-10-13.

- added to_clipboard.
- added embryonic documentation.
- added sort_columns and na arguments to read_hdf.
- added sort_rows, sort_columns and na arguments to read_excel.
- added setup.py to install the module.
- IO functions (to_*/read_*) now support unnamed axes. The set of supported operations is very limited with such arrays though.
- to_excel sheet_name defaults to "Sheet1" like in Pandas.
- reorganised files.
- automated somewhat releases (added a rudimentary release script).
- column titles are no longer converted to lowercase.

6.1.50 Version 0.1

Released on 2014-10-22.

6.2 How to contribute

6.2.1 Before Starting

Where to find the code

The code is hosted on GitHub.

Tools

To contribute you will need to sign up for a free GitHub account.

We use Git for version control to allow many people to work together on the project.

The documentation is written partly using reStructuredText and partly using Jupyter notebooks (for the tutorial). It is built to various formats using Sphinx and nbsphinx.

The unit tests are written using the pytest library. The compliance with the PEP8 conventions is tested using the extension pytest-pep8.

Many editors and IDE exist to edit Python code and provide integration with version control tools (like git). A good IDE, such as PyCharm, can make many of the steps below much more efficient.

Licensing

LArray is licensed under the GPLv3. Before starting to work on any issue, make sure you accept and are allowed to have your contributions released under that license.

6.2.2 Creating a development environment

Getting started with Git

GitHub has instructions for installing and configuring git.

Getting the code (for the first time)

You will need your own fork to work on the code. Go to the larray project page and hit the `Fork` button.

You will want to clone your fork to your machine. To do it manually, follow these steps:

```
git clone https://github.com/your-user-name/larray.git
cd larray
git remote add upstream https://github.com/larray-project/larray.git
```

This creates the directory *larray* and connects your repository to the upstream (main project) *larray* repository. You can see the remote repositories:

```
git remote -v
```

If you added the upstream repository as described above you will see something like:

```
origin  git@github.com:yourname/larray.git (fetch)
origin  git@github.com:yourname/larray.git (push)
upstream        git://github.com/larray-project/larray.git (fetch)
upstream        git://github.com/larray-project/larray.git (push)
```

Creating a Python Environment

Before starting any development, you will need a working Python installation. It is recommended (but not required) to create an isolated larray development environment. One of the easiest way to do it is via *Anaconda* or *Miniconda*:

- Install either Anaconda or miniconda as *suggest earlier*
- Make sure your conda is up to date (`conda update conda`)
- Make sure that you have *cloned the repository*
- `cd` to the *larray* source directory

We'll now kick off a two-step process:

1. Install the build dependencies

```
# add 'conda-forge' channel (required to install some dependencies)
conda config --add channels conda-forge

# Create and activate the build environment
conda create -n larray_dev numpy pandas pytables pyqt qtpy matplotlib xlrd openpyxl␣
↪xlsxwriter pytest pytest-pep8
conda activate larray_dev
```

This will create the new environment, and not touch any of your existing environments, nor any existing Python installation.

To view your environments:

```
conda info -e
```

To return to your root environment:

```
conda deactivate
```

See the full conda docs here.

2. Build and install larray

Install larray using the following command:

```
python setup.py develop
```

This creates some kind of symbolic link between your python installation "modules" directory and your repository, so that any change in your local copy is automatically usable by other modules.

At this point you should be able to import larray from your local version:

```
$ python  # start an interpreter
>>> import larray
>>> larray.__version__
'0.29-dev'
```

6.2.3 Starting to contribute

With your local version of larray, you are now ready to contribute to the project. To make a contribution, please follow the steps described bellow.

Step 1: Create a new branch

You want your master branch to reflect only production-ready code, so create a feature branch for making your changes. For example:

```
git checkout -b issue123
```

This changes your working directory to the issue123 branch. Keep any changes in this branch specific to one bug or feature so it is clear what the branch brings to the project. You can have many different branches and switch between them using the `git checkout` command.

To update this branch, you need to retrieve the changes from the master branch:

```
git fetch upstream
git rebase upstream/master
```

This will replay your commits on top of the latest larray git master. If this leads to merge conflicts, you must resolve these before submitting your pull request. If you have uncommitted changes, you will need to `stash` them prior to updating. This will effectively store your changes and they can be reapplied after updating.

Step 2: Write your code

When writing your code, please follow the PEP8 code conventions. Among others, this means:

- 120 characters lines
- 4 spaces indentation
- lowercase (with underscores if needed) variables, functions, methods and modules names
- CamelCase classes names
- all uppercase constants names
- whitespace around binary operators
- no whitespace before a comma, semicolon, colon or opening parenthesis
- whitespace after commas

This summary should not prevent you from reading the PEP!

LArray is currently compatible with both Python 2 and 3. So make sure your code is compatible with both versions.

Step 3: Document your code

We use Numpy conventions for docstrings. Here is a template:

```
def funcname(arg1, arg2=default2, arg3=default3):
    """Summary line.

    Extended description of function.

```

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```
    .. versionadded:: 0.2.0

    Parameters
    ----------
    arg1 : type1
        Description of arg1.
    arg2 : {value1, value2, value3}, optional
        Description of arg2.

        * value1 -- description of value1 (default2)
        * value2 -- description of value2
        * value3 -- description of value3
    arg3 : type3 or type3bis, optional
        Description of arg3. Default is default3.

        .. versionadded:: 0.3.0

    Returns
    -------
    type
        Description of return value.

    Notes
    -----
    Some interesting facts about this function.

    See Also
    --------
    LArray.otherfunc : How other function or method is related.

    Examples
    --------
    >>> funcname(arg)
    result
    """
```

For example:

```
def check_number_string(number, string="1"):
    """Compares the string representation of a number to a string.

    Parameters
    ----------
    number : int
        The number to test.
    string : str, optional
        The string to test against. Default is "1".

    Returns
    -------
    bool
        Whether the string representation of the number is equal to the string.

    Examples
    --------
    >>> check_number_string(42, "42")
    True
```

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```
    >>> check_number_string(25, "2")
    False
    >>> check_number_string(1)
    True
    """
    return str(number) == string
```

Step 4: Test your code

Our unit tests are written using the pytest library and our tests modules are located in */larray/tests/*. We also use its extension pytest-pep8 to check if the code is PEP8 compliant. The pytest library is able to automatically detect and run unit tests as long as you respect some conventions:

- pytest will search for `test_*.py` or `*_test.py files`.
- From those files, collect test items:
  - `test_` prefixed test functions or methods outside of class.
  - `test_` prefixed test functions or methods inside Test prefixed test classes (without an __init__ method).

For more details, please read the section Conventions for Python test discovery from the pytest documentation.

Here is an example of a unit test function using pytest:

```
from larray.core.axis import _to_key

def test_key_string_split():
    assert _to_key('M,F') == ['M', 'F']
    assert _to_key('M,') == ['M']
```

To run unit tests for a given test module:

```
> pytest larray/tests/test_array.py
```

We also use doctests for some tests. Doctests is specially-formatted code within the docstring of a function which embeds the result of calling said function with a particular set of arguments. This can be used both as documentation and testing. We only use doctests for the cases where the test is simple enough to fit on one line and it can help understand what the function does. For example:

```
def slice_to_str(key):
    """Converts a slice to a string

    >>> slice_to_str(slice(None))
    ':'
    """
    # some clever code here
    return ':'
```

To run doc tests:

```
> pytest larray/core/array.py
```

To run all the tests, simply go to root directory and type:

```
> pytest
```

pytest will automatically detect all existing unit tests and doctests and run them all.

Step 5: Add a change log

Changes should be reflected in the release notes located in `doc/source/changes/version_<next_release_version>.inc`. This file contains an ongoing change log for the next release. Add an entry to this file to document your fix, enhancement or (unavoidable) breaking change. If you hesitate in which section to add your change log, feel free to ask. Make sure to include the GitHub issue number when adding your entry (using ``closes :issue:`123` `` where 123 is the number associated with the fixed issue).

Step 6: Commit your changes

When all the above is done, commit your changes. Make sure that one of your commit messages starts with `fix #123 :` (where 123 is the issue number) before starting any pull request (see this github page for more details).

Step 7: Push your changes

When you want your changes to appear publicly on the web page of your fork on GitHub, push your forked feature branch's commits:

```
git push origin issue123
```

Here `origin` is the default name given to your remote repository on GitHub.

Step 8: Start a pull request

You are ready to request your changes to be included in the master branch (so that they will be available in the next release). To submit a pull request:

1. Navigate to your repository on GitHub
2. Click on the `Pull Request` button
3. You can then click on `Commits` and `Files Changed` to make sure everything looks okay one last time
4. Write a description of your changes in the `Preview Discussion` tab
5. If this is your first pull request, please state explicitly that you accept and are allowed to have your contribution (and any future contribution) licensed under the GPL license (See section *Licensing* above).
6. Click `Send Pull Request`.

This request then goes to the repository maintainers, and they will review the code. Your modifications will also be automatically tested by running the *larray* test suite on Travis-CI continuous integration service. A pull request will only be considered for merging when you have an all 'green' build. If any tests are failing, then you will get a red 'X', where you can click through to see the individual failed tests.

If you need to make more changes to fix test failures or to take our comments into account, you can make them in your branch, add them to a new commit and push them to GitHub using:

```
git push origin issue123
```

This will automatically update your pull request with the latest code and trigger the automated tests again.

`Warning`: Please do not rebase your local branch during the review process.

6.2.4 Documentation

The documentation is written using reStructuredText and built to various formats using Sphinx. See the reStructured-Text Primer for a first introduction of the syntax.

Installing Requirements

Basic requirements (to generate an .html version of the documentation) can be installed using:

```
> conda install sphinx numpydoc nbsphinx
```

To build the .pdf version, you need a LaTeX processor. We use MiKTeX.

To build the .chm version, you need HTML Help Workshop.

Generating the documentation

Open a command prompt and go to the documentation directory:

```
> cd doc
```

If you just want to check that there is no syntax error in the documentation and that it formats properly, it is usually enough to only generate the .html version, by using:

```
> make html
```

Open the result in your favourite web browser. It is located in:

```
build/html/index.html
```

If you want to also generate the .pdf and .chm (and you have the extra requirements to generate those), you could use:

```
> buildall
```

BIBLIOGRAPHY

[1] Wikipedia, "Convolution", https://en.wikipedia.org/wiki/Convolution

[1] C. W. Clenshaw, "Chebyshev series for mathematical functions", in *National Physical Laboratory Mathematical Tables*, vol. 5, London: Her Majesty's Stationery Office, 1962.

[2] M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions*, 10th printing, New York: Dover, 1964, pp. 379. http://www.math.sfu.ca/~cbm/aands/page_379.htm

[3] http://kobesearch.cpan.org/htdocs/Math-Cephes/Math/Cephes.html

[1] Weisstein, Eric W. "Sinc Function." From MathWorld–A Wolfram Web Resource. http://mathworld.wolfram.com/SincFunction.html

[2] Wikipedia, "Sinc function", https://en.wikipedia.org/wiki/Sinc_function

[1] Wikipedia, "Exponential function", https://en.wikipedia.org/wiki/Exponential_function

[2] M. Abramovitz and I. A. Stegun, "Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables," Dover, 1964, p. 69, http://www.math.sfu.ca/~cbm/aands/page_69.htm

[1] M. Abramowitz and I.A. Stegun, "Handbook of Mathematical Functions", 10th printing, 1964, pp. 67. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, "Logarithm". https://en.wikipedia.org/wiki/Logarithm

[1] M. Abramowitz and I.A. Stegun, "Handbook of Mathematical Functions", 10th printing, 1964, pp. 67. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, "Logarithm". https://en.wikipedia.org/wiki/Logarithm

[1] M. Abramowitz and I.A. Stegun, "Handbook of Mathematical Functions", 10th printing, 1964, pp. 67. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, "Logarithm". https://en.wikipedia.org/wiki/Logarithm

[1] ISO/IEC standard 9899:1999, "Programming language C."

[1] M. Abramowitz and I. A. Stegun, Handbook of Mathematical Functions. New York, NY: Dover, 1972, pg. 83. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, "Hyperbolic function", https://en.wikipedia.org/wiki/Hyperbolic_function

[1] M. Abramowitz and I.A. Stegun, "Handbook of Mathematical Functions", 10th printing, 1964, pp. 86. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, "Inverse hyperbolic function", https://en.wikipedia.org/wiki/Arcsinh

[1] M. Abramowitz and I.A. Stegun, "Handbook of Mathematical Functions", 10th printing, 1964, pp. 86. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, “Inverse hyperbolic function”, https://en.wikipedia.org/wiki/Arccosh

[1] M. Abramowitz and I.A. Stegun, “Handbook of Mathematical Functions”, 10th printing, 1964, pp. 86. http://www.math.sfu.ca/~cbm/aands/

[2] Wikipedia, “Inverse hyperbolic function”, https://en.wikipedia.org/wiki/Arctanh

[1] Wikipedia, “Normal distribution”, http://en.wikipedia.org/wiki/Normal_distribution

[2] P. R. Peebles Jr., “Central Limit Theorem” in “Probability, Random Variables and Random Signal Principles”, 4th ed., 2001, pp. 51, 51, 125.

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