

# Tools for data analyses in Cosmology

## - Aula 3 -

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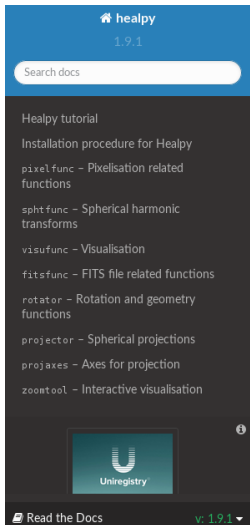
Observatório Nacional

May 16, 2017

# Installation

Healpy ✓

# Healpy: Online Documentation \*



The screenshot shows the left sidebar of the Healpy documentation website. At the top is a blue header with the Healpy logo and version 1.9.1. Below it is a search bar labeled 'Search docs'. A list of navigation links follows: 'Healpy tutorial', 'Installation procedure for Healpy', 'pixelfunc - Pixelisation related functions', 'sphthfunc - Spherical harmonic transforms', 'visufunc - Visualisation', 'fitsfunc - FITS file related functions', 'rotator - Rotation and geometry functions', 'projector - Spherical projections', 'projaxes - Axes for projection', and 'zoomtool - Interactive visualisation'. At the bottom is a 'Uniregistry' logo and a 'Read the Docs' button with a version dropdown set to 'v: 1.9.1'.

[Docs](#) » Welcome to healpy documentation!

[Edit on GitHub](#)

## Note

You are not using the most up to date version of the library. [1.10.3](#) is the newest version.

## Welcome to healpy documentation!

### Tutorial

- [Healpy tutorial](#)

### Installation

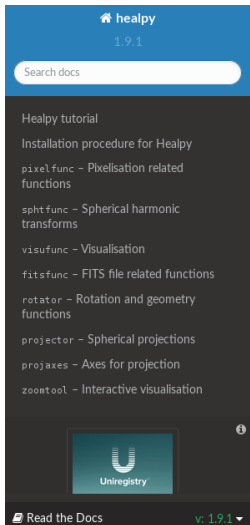
- [Installation procedure for Healpy](#)

### Reference

- [pixelfunc](#) - Pixelisation related functions
  - [conversion from/to sky coordinates](#)
  - [conversion between NESTED and RING schemes](#)
  - [nside/npix/resolution](#)
  - [Masking pixels](#)

\* Note: We will follow Healpy version 1.9.1

# Healpy: Online Documentation \*



The screenshot shows the top part of the Healpy website. At the top, there is a blue header with the 'healpy' logo and the version number '1.9.1'. Below the header is a white search bar with the text 'Search docs'. A dark grey navigation menu follows, listing various topics: 'Healpy tutorial', 'Installation procedure for Healpy', 'pixelfunc - Pixelisation related functions', 'sphtfunc - Spherical harmonic transforms', 'visufunc - Visualisation', 'fitsfunc - FITS file related functions', 'rotator - Rotation and geometry functions', 'projector - Spherical projections', 'projaxes - Axes for projection', and 'zoomtool - Interactive visualisation'. At the bottom of the menu is a 'Uniregistry' logo and a 'Read the Docs' button. The version 'v: 1.9.1' is displayed in the bottom right corner of the menu.

## Reference

- **pixelfunc** - Pixelisation related functions
  - conversion from/to sky coordinates
  - conversion between NESTED and RING schemes
  - nside/npix/resolution
  - Masking pixels
  - Map data manipulation
- **sphtfunc** - Spherical harmonic transforms
  - From map to spherical harmonics
  - From spherical harmonics to map
  - Spherical harmonic transform tools
  - Other tools
- **visufunc** - Visualisation
  - Map projections
  - Graticules
  - Tracing lines or points
- **fitsfunc** - FITS file related functions
  - Reading/writing maps
  - Reading/writing alm
  - Reading/writing cl
  - Reading/writing column in fits file
  - Helper
- **rotator** - Rotation and geometry functions
  - Rotation
  - Geometrical helpers
- **projector** - Spherical projections
  - Basic classes
- **projaxes** - Axes for projection
  - Basic classes
- **zoomtool** - Interactive visualisation
  - Interactive map visualization

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[Edit on GitHub](#)

version of the library. **1.10.3** is the newest version.

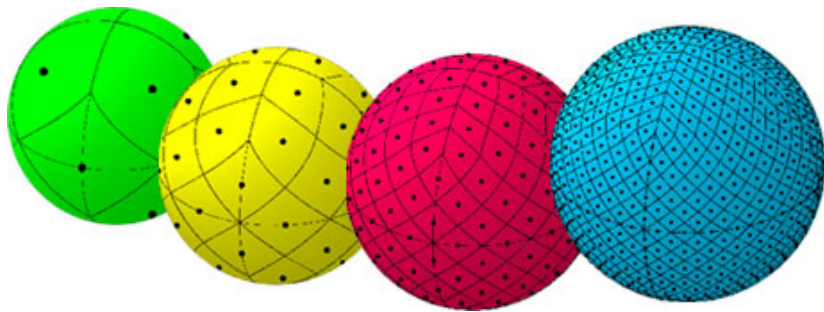
## Documentation!

ons

ING schemes

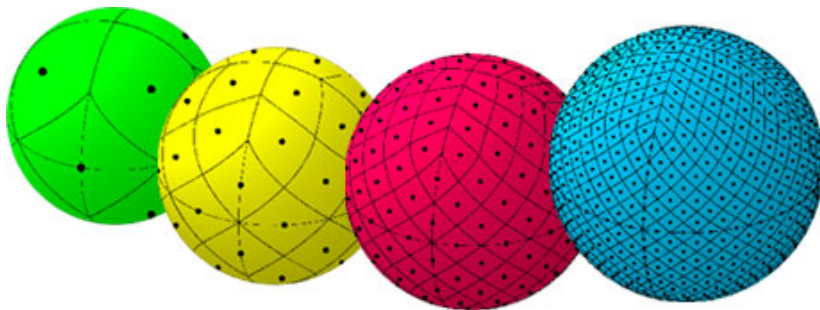
\* Note: We will follow Healpy version 1.9.1

Ready to start ...



# Overview

- Read and write special<sup>1</sup> **FITS** files,
- Visualise the data in diverse projection types, and more ...



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<sup>1</sup>Data maps

First of all ...

- In the editor, import the packages you will need:

```
import heapy as hp
import numpy as np
...
```

- Syntax:

```
... hp.routine_name ...
```

## Reading a map

### healpy.fitsfunc.read\_map

```
healpy.fitsfunc.read_map(filename, field=0, dtype=<type 'numpy.float64'>, nest=False, partial=False, hdu=1, h=False, verbose=True, memmap=False)
```

Read an healpix map from a fits file. Partial-sky files, if properly identified, are expanded to full size and filled with UNSEEN.

#### Parameters:

- filename : fits file name
- field : column to read (Default: 0.)
- dtype : data type, optional (Default: np.float64)
- nest : bool (True or False)
- partial : bool (True or False)
- hdu : int, header number (start at 0)
- h : bool, if True, return also the header. (Default: False.)
- verbose : bool, if True, print a number of diagnostic messages.
- memmap : bool, if True, the map is not read into memory, the required pixels are read when needed. (Default: False).



## Reading a map

How to use:

```
In [1]: import healpy as hp
```

```
In [2]: mapa = hp.read_map('COM_CMB_IQU-commander_0256_R2.00.fits',  
field={0,1,2}, h=True, nest=True)  
NSIDE = 256  
ORDERING = NESTED in fits file  
INDXSCHM = IMPLICIT
```

```
In [3]:
```

What is a map in python?

```
mapa_ex = list(range(192))  
hp.mollview(mapa_ex)           # it DOES NOT work  
hp.mollview(np.array(mapa_ex)) # it DOES work
```

# Visualizing a map in a Mollweide projection

## healpy.visufunc.mollview

```
healpy.visufunc.mollview(map=None, fig=None, rot=None, coord=None, unit="", xsize=800, title='Mollweide view', nest=False, min=None, max=None, flip='astro', remove_dip=False, remove_mono=False, gal_cut=0, format='%g', format2='%g', cbar=True, cmap=None, notext=False, norm=None, hold=False, margins=None, sub=None, return_projected_map=False)
```

Plot an healpix map (given as an array) in Mollweide projection.

Main parameters:

- map : float, array-like or None
- rot : scalar or sequence. In the form (lon, lat, psi) (unit: degrees)
- coord : sequence of character, 'G', 'E' or 'C' .
- unit : str, Default: ' '
- xsize : int, size of the image. Default: 800
- title : str, title of the plot. Default: 'Mollweide view'
- nest : bool. Default: False (RING)
- + min, max, remove\_dip, remove\_mono, ...

## Visualizing a map in a Mollweide projection

How to use:

```
In [6]: from matplotlib import pyplot
```

```
In [7]: mollview_fig = hp.mollview(mapa[0], nest=True,  
norm='hist', coord=['G','E'])  
...: pyplot.savefig('mollweide_view.png')
```

## Exercise

- Download one of the Planck maps.  
[<http://pla.esac.esa.int/pla/>]
- Read it using healpy.
- Visualize the header information. (use `list()` command)
- Plot the map in Mollweide projection (each column).
  - Try: rotation of `[0,210,70]`, include unit, change the title, change the scale, histogram equalized color mapping (norm = 'hist'), change coordinates (coord=['G','E']), ...
- If you want to save the figure, remind:
  - `from matplotlib import pyplot`
  - `hp.mollview(...)`
  - `pyplot.savefig('path/name_file.png')`

## Results

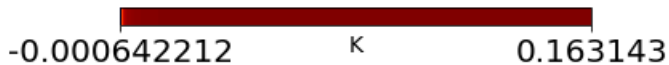
Header:

```
[('XTENSION', 'BINTABLE'),  
...  
( 'NAXIS2', 12582912),  
... ('COMMENT', ' *** Column names ***'),  
( 'TTYPE1', 'C030'),  
( 'TTYPE2', 'C044'),  
( 'TTYPE3', 'C070'),  
...  
( 'COMMENT', ' *** Column units ***'),  
( 'TUNIT1', 'K_CMB'),  
( 'TUNIT2', 'K_CMB'),  
( 'TUNIT3', 'K_CMB'),  
( 'COMMENT', ' *** Planck params ***'),  
( 'EXTNAME', 'LFI-RESID'),  
( 'AST-COMP', 'FOREGDS'),  
( 'PIXTYPE', 'HEALPIX'),  
( 'COORDSYS', 'GALACTIC'),  
( 'ORDERING', 'NESTED'),  
  ( 'NSIDE', 1024),  
( 'FIRSTPIX', 0),  
( 'LASTPIX', 12582911),
```

Result

Mollweide view

Ecliptic



# Results

Rotating the map and including the units / changing the scale:

