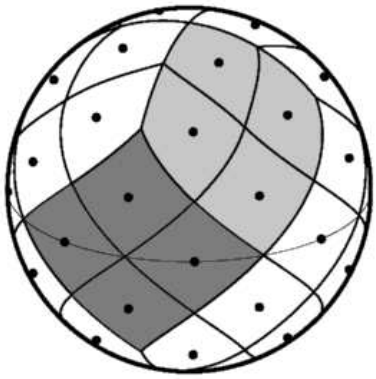
HEALPix IDL Facilities Overview



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Abstract: This document is an overview of the **HEALPix** IDL facilities.

https://healpix.sourceforge.io
http://healpix.sf.net

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Using the HEALPix-IDL facilities

The current version of the **HEALPix** package provides an IDL startup file which defines various environment variables for your convenience, and adds the **HEALPix** IDL directory tree to your `IDL_PATH`. In order to utilise this feature, the user should invoke IDL using the commands `hidl` or `hidlde` which are aliases defined in the **HEALPix** profile created during the installation process for the package (see the Installation Document).

Using HEALPix-IDL together with other IDL libraries

Many users want to use **HEALPix**-IDL routines at the same time as other (home made or third party[1]) IDL routines. There are several ways to achieve this:
– *with* `hidl`*:*
before starting `hidl` or `hidlde`, (re)define the environment variable `$IDL_PATH` so that it looks like: "`+`*/path/to/my/idl/routines*`:+`*/path/to/other/idl/routines*`:<IDL_DEFAULT>`" (where `<IDL_DEFAULT>` should be typed literally and the `+`*/path* means that subdirectories of *path* will be searched recursively). For example, if young Albert types in Bourne shell:

```
export IDL_PATH="+/home/aeinstein/brownian:<IDL_DEFAULT>"
hidl
```

he will start an IDL session in which the **HEALPix**-IDL routines are accessible, followed by all those located in subdirectories of `/home/aeinstein/brownian`, followed by the standard IDL routines. If `.pro` files of the same name are avaible at the different locations, the first one encountered will prevail;
– *without* `hidl`*:*
before starting IDL, the environment variables `$IDL_PATH` and `$IDL_STARTUP` must be defined. For instance, to emulate under (`ba`)`sh` the behavior of `hidl` shown above, the same (bolder) Albert will type:

```
export IDL_PATH="+${HEALPIX}/src/idl:+/home/aeinstein/brownian:<IDL_DEFAULT>"
export IDL_STARTUP="+${HEALPIX}/src/idl/HEALPix_startup"
idl
```

FL users will do exactly the same thing, replacing `hidl` with `hfl` and `idl` with `fl64_cmd` (or `fl32_cmd`).
As for **GDL users**, they will replace `hidl`, `IDL_PATH` and `IDL_STARTUP` above with `hgdl`, `GDL_PATH` and `GDL_STARTUP` respectively, while `<IDL_DEFAULT>` must be replaced by the default value of `${GDL_PATH}`.
Of course, `${HEALPIX}/src/idl` (and all the `+` signs) remain unchanged.

[1] An extensive list of third party IDL libraries can be found at https://idlastro.gsfc.nasa.gov/other_url.html. Among them, we recommend the IDL Astronomy Users library (https://idlastro.gsfc.nasa.gov) maintained by Wayne Landsman and which is extensively used in **HEALPix**-IDL, David Fanning's IDL Coyote library (http://www.idlcoyote.com) from which some routines are used in **HEALPix**-IDL, and Craig Markwardt's IDL library (https://cow.physics.wisc.edu/~craigm/idl/idl.html).

Using GDL or FL instead of IDL

See the sections "Using GDL instead of IDL" or "Using FL instead of IDL" in the Installation Document for more information on these topics.

What is available?

The **HEALPix**-IDL tools are mostly designed to generate, visualize, filter and analyze sky maps; identify, query and process **HEALPix** pixels; and deal with angular spectral objects (such as power spectra or Spherical Harmonics coefficients), as detailed below. The full documentation is available online in IDL via `healpix_doc`

HEALPix maps related tools

- Visualization: gnomic, Mollweide, Cartesian, orthographic and azimuthal equatorial projections `mollview`, `gnomview`, `cartview`, `orthview`, `azeqview` (with interactive cursor: `cartcursor`, `mollcursor`, `gnomcursor`, `orthcursor`)
- Color table creation: `planck_colors`
- Production of **HEALPix** maps in Google Sky and Dome Master format: `hpx2gs`, `hpx2dm`.
- Spherical Harmonics analysis and synthesis: `ianafast`, `isynfast`.
- Smoothing and filtering: `ismoothing`, `median_filter`, `remove_dipole`.
- Handling of quadrature weights: `nside2npweights`, `unfold_weights`.
- Pixel pro/down-grading and NESTED/RING pixel reordering: `ud_grade`, `reorder`.
- Mask processing: `iprocess_mask`
- Maps I/O: `read_fits_cut4`, `read_fits_map`, `read_fits_s`, `read_tqu`. `write_fits_cut4`, `write_fits_map`, `write_fits_sb`, `write_tqu`. `getsize_fits`, `change_polcconv`

HEALPix pixels related tools

- Coordinate tools: `ang2vec`, `angulardistance`, `euler_matrix_new`, `rotate_coord`, `vec2ang`
- Coordinates to pixel transforms, and back: `nside2npix`, `npix2nside`, `ang2pix_*`, `pix2ang_*`, `pix2vec_*`, `vec2pix_*`

- RING/NESTED transforms: `nest2ring, ring2nest`
- Unique Identifier to NESTED index, and back: `uniq2nest`, `nest2uniq`
- Neighbouring pixels: `neighbours_nest`, `neighbours_ring`
- Pixel query within a disc, polygon, strip or triangle: `query_disc`, `query_polygon`, `query_strip`, `query_triangle`.
- Template pixels: `nside2ntemplates`, `same_shape_pixels_ring`, `same_shape_pixels_nest`, `template_pixel_ring`, `template_pixel_nest`

Power spectrum, $a_{\ell m}$, beam and pixel window functions

- $B(\ell)$, $B(\theta)$ and pixel WF generation: `gaussbeam`, `beam2bl`, `bl2beam`, `healpixwindow`
- $C(\ell)$ binning: `bin_llcl`
- $a_{\ell m}$ handling tools: `alm_i2t`, `alm_t2i`, `index2lm`, `lm2index`, `ialteralm`
- $C(\ell)$, $B(\ell)$ and $a_{\ell m}$ I/O: `fits2cl`/`cl2fits`, `bl2fits`, `fits2alm`/`alm2fits`,

Other tools

- **HEALPix** variables and paths initialization: `init_healpix`
- online documentation: `healpix_doc`
- recursive `help` on IDL sub-structures: `help_st`

Changes between releases 3.40 and 3.50

- `fits2cl`: addition of `/PLANCK3` keyword to read the fiducial Λ-CDM $C(\ell)$ model which best fits the 2018 Planck data analysis (available from `Healpix/data/planck2018_lcdm_cl_v3.fits`);
- `rotate_coord`: addition of optional variable `Delta_Psi` containing rotation of polarization on output, and of keyword `Free_Norm` to deal with un-normalized input coordinate vectors

Changes between releases 3.31 and 3.40

- The routines `ianafast` and `ismoothing` can now use pixel-based quadrature weights. Addition of the supporting functions `nside2npweights` and `unfold_weights`.
- `ianafast` and `ismoothing`: test the value of the `POLCCONV` FITS keyword when reading a polarized map, and interpret the polarization accordingly, as described in the note on POLCCONV in The **HEALPix** Primer.
- `change_polcconv` has been improved to allow the change of polarization convention (by changing the sign of U Stokes parameter and updating `POLCCONV` value) in FITS files containing polarized maps generated by standard **HEALPix** tools, as well as for specific formats brewed by the WMAP and Planck projects throughout the years. An equivalent python facility `change_polcconv.py` is now available as well.
- New `help_st` to get information on a structure and its sub-structures
- `azeqview, cartview, gnomview, mollview, orthview` visualization routines:
  - addition of the keywords `CUSTOMIZE` and `DEFAULT_SETTINGS` for extensize customization of the figures produced
  - `GLSIZE` and `IGLSIZE` can now be 2-element vectors to control separately the size (and presence) of labels on the parallel and meridian graticules
  - fine control of polarisation rods thickness with `POLARIZATION`
  - addition of the `SILHOUETTE` keyword to add a tunable silhouette around the projected map (`mollview` and `orthview` only)
- Improved support for GDL and FL (Fawlty Language).
- Update of the required `IDL-astron` library routines, and `Coyote` library routines (2018-05-15).

Previous changes

Changes between releases 3.30 and 3.31

- Improved support for GDL;
- update of the required IDL-astron library routines, and Coyote library routines (2016-08-19).

Changes between releases 3.20 and 3.30

- azeqview, cartview, gnomview, mollview, orthview visualization routines:
  - addition of PDF keyword for production of Adobe PDF outputs;
  - addition of LATEX keyword for genuine or emulated LaTeX processing of character strings;
  - addition of PFONTS keyword to select origin and type of character font;
  - the CROP keyword now has the same behavior for all output media (GIF, JPEG, PDF, PNG, PS, ... and X); the NOBAR keyword now removes the color bar *or* the polarization color wheel, as applicable; correct EQUINOX date in header of output FITS map; the double precision maps and those with constant value are now correctly handled.
- fits2cl: addition of /PLANCK2 keyword to read best fit $C(\ell)$ model to Planck 2015 data.
- new routines nest2uniq and uniq2nest for conversion of standard pixel index to/from Unique ID number. See "The Unique Identifier scheme" section in "**HEALPix** Introduction Document" for more details.
- **HEALPix** enabled GDL commands (`hgdl` and `hgdlde`) are defined during the configuration process.
- update of the required IDL-astron library routines, and Coyote library routines (2015-09-23).

Changes between releases 3.11 and 3.20

- addition of ialteralm to modify Spherical Harmonics coefficients ($a_{\ell m}$).
- addition of planck_colors to modify current color table to one used in Planck 2013 publications.
- cartview, gnomview, mollview, orthview:
  - addition of BAD_COLOR, BG_COLOR and FG_COLOR keywords to change the color of the missing pixels, background and foreground labels and lines.
  - support for COLT='planck1' and COLT='planck2' to use the Planck color tables defined in planck_colors
- Bugs correction in bin_llcl, query_disc.
- update of the required IDL-astron library routines, and their supporting Coyote routines (2014-11-10).

Changes between releases 3.00 and 3.11

- Latest edition (version 3.11)
  - ang2pix_ring and pix2ang_nest routines now accept scalar arguments
- Previous edition (version 3.10)
  - bug corrections: query_disc: correct handling of empty disc; bin_llcl: correct handling of optional argument.
  - double precision of input now preserved in gaussbeam and euler_matrix_new.
  - fits2cl: addition of /PLANCK1 keyword to read best fit $C(\ell)$ model to Planck 2013 + external data.
  - it is now possible to read a specific FITS file extension identified by its (0-based) number or its case-insensitive EXTNAME value with the `Extension` keyword added to fits2cl, getsize_fits, read_fits_map, read_fits_s and read_tqu.
  - update of the required IDL-astron library routines, and their supporting Coyote routines (2013-02-08).

Changes between releases 2.20 and 3.00

- Previous edition (version 3.0)
  - New routines to go from circular beam profile to transfer function (beam2bl), and back (bl2beam); to go from indexed list of $a_{\ell m}$ to a(l,m) 2D table (alm_i2t), and back (alm_t2i); and to compute the angular distance between pairs of vectors (angulardistance).
  - addition of iprocess_mask interface to F90 process_mask facility to compute the angular distance of valid pixels to the closest invalid pixels for a input binary mask.
  - creation of hpx2dm routine to generate DomeMaster images of **HEALPix** maps that can be projected on planetariums.
  - the pixel query routines query_triangle, query_polygon, and in particular query_disc, have been improved and will return fewer false positive pixels in the *inclusive* mode
  - improved accuracy of the co-latitude calculation in the vicinity of the poles for high resolution in nest2ring, ring2nest, pix2ang_*, pix2vec_*, ...
  - cartview, gnomview, mollview, orthview: the length and spacing of the headless vectors used to represent polarization is now user-controlled via POLARIZATION keyword. The COLT keyword now allows the use of an interactively modified color table.
  - orthview now accepts STAGGER keyword to overplot staggered spheres (with a twist) in order to detect periodic boundary conditions on the sky
  - fits2cl: addition of WMAP7 keyword to read best fit $C(\ell)$ model to WMAP 7yr data.
  - read_fits_map can now read $N_{\rm side}$=8192 **HEALPix** maps and is generally faster than previously for smaller maps
  - update of astron library routines (01-Feb-2012).

Changes between release 2.0 and 2.20

Several routines have been added or improved since version 2.0, as listed below. Note that thanks to the newer IDL-astron library, FITS read/write routines in IDL-Healpix routines can now deal with **FITS files larger than 2GB** (on architectures supporting 64bit addressing).
Using 64 bit integers available since version 5.2 of IDL the maximum resolution parameter Nside supported has increased from $2^{13} = 8192$ to $2^{29} = 536870912$, corresponding to 3.46 10^{18} pixels on the sphere.

- Recent edition (versions 2.20 and 2.20a)
  - fits2cl: addition of WMAP1 and WMAP5 keywords to read best fit $C(\ell)$ model to WMAP 1st and 5yr data respectively,
  - cartview, gnomview, mollview, orthview: the OUTLINE option now accept symbols with PSYM > 8, using cgsymcat symbols definition.
- Recent editions (versions 2.15 and 2.15a)
  - cartview, gnomview, mollview, orthview:
    - export of projected map into a FITS file (FITS keyword), or an IDL array (MAP_OUT option) now available with all viewing routines,
    - added CHARTHICK support; accept array of OUTLINE structures (if they have the same fields), and still support structure of structures,
    - correction of a bug (in loaddata_healpix) that was affecting the behavior of these viewing routines after consecutive calls with very partial cut-sky *and then* full-sky data sets [2.15a];
  - remove_dipole now outputs the monopole and dipole covariance matrix;
  - write_fits_map, write_tqu, write_fits_sb: BAD_DATA keyword added to FITS header;
  - update of astron library routines (24-May-2010) for improved WCS support.
- Previous edition (version 2.14a)
  - cartview, gnomview, mollview, orthview:
    - OUTLINE=, GRATICULE=, IGRATICULE= work again with virtual windows (WINDOW< 0)

    - YPOS= and RETAIN= keywords active again
    - PS= keyword fixed
  - orthview: fixed problems with /SHADE keyword, which now outputs 8-byte (instead of 16-byte) PNG files
  - ianafast, ismoothing: fixed problem with processing of polarized maps stored in memory.
  - ud_grade: improved handling of flagged pixels on Double Precision input maps
  - remove_dipole: COORD_IN= and COORD_OUT= now accept lower case values; /SILENT keyword added.

- Old edition (version 2.13)
  - new healpix_doc routine to browse HTML and PDF documentations
  - cartview, gnomview, mollview, orthview:
    - introduction of the TRUECOLORS= keyword to generate color image from 3 channel map
    - extended capability of the TRANSPARENT= keyword
    - addition of MAP_OUT= to gnomview
  - improved compatibility with GDL (free IDL clone). See "**HEALPix** Installation Document" for current GDL limitations.
  - update of the IDL-astron library routines, which now require IDL 6.1 or more
  - fits2alm: new LMAX= and LMIN= keywords
  - fits2cl: new LLFACTOR= keyword
  - init_healpix defines substructure with complete path to **HEALPix** subdirectories (test, data, bin)
  - slightly faster write_fits_cut4 and write_fits_sb routines.
  - ianafast, ismoothing: solved problem with W8DIR= keyword.

- Older editions (versions 2.11 and 2.12a)
  - ianafast, ismoothing, isynfast: the TMPDIR keyword now works properly, and $IDL_TMPDIR is used as the default temporary directory ; more stable behaviour of these routines
  - ud_grade:
    - correctly flags bad output pixels with bad_data value when upgrading maps
    - cut sky map: improved, faster routine, now works for Nside $>$ 8192
  - cartview, gnomview, mollview, orthview:
    - using a virtual window (ie, setting WINDOW to a negative value) now allows faster generation of GIF and PNG files (especially useful over remote connections);
    - addition of RETAIN= keyword;
    - deals correctly with user provided MIN and MAX in LOG and ASINH modes
    - polarization norm map can be offset (POLARIZATION=1 mode)
    - original color table and plot settings are restored when leaving these routines
  - orthview: addition of /SHADED keyword for 3D rendering
  - issues warning when non-integer pixel indexes are fed to nest2ring, ring2nest, pix2ang_*, pix2vec_*, ...
  - ximview:
    - fixed problem with cut-sky FITS files
    - color scale bar added to PNG output
    - version 0.6.2, fixed bug in pixel coordinates
  - cosmetic editions to remove_dipole

- New routines in version 2.10 include
  - ximview: visualisation routine developed by J. P. Leahy intended for quick-look inspection of HEALPix images (as well as ordinary 2-D images) at the level of individual pixels. Features include panning, zooming, blinking, image statistics and peak finding.
  - hpx2gs: turns a healpix data set into a Google Earth/Google Sky-compatible image

  - `ianafast`: interface to (F90) `anafast` and (C++) `anafast_cxx` facilities
  - `isynfast`: interface to F90 `synfast` facility
  - `ismoothing`: interface to F90 `smoothing` facility
  - `bin_llcl`: $C(\ell)$ binning
  - `bl2fits`: writes $B(\ell)$ or $W(\ell)$ window into FITS file
  - `neighbours_nest`, `neighbours_ring`: find immediate neighbours of a given pixel
  - `query_strip`: find pixels lying within a colatitude strip

- Routines with extended/improved user interface or new functionalities include
  - `mollview, gnomview, cartview, orthview`:
    * `ONLINE` keyword is now redundant,
    * introduction of `GLSIZE` and `IGLSIZE` to control automatic labeling of graticules, see Fig. 2 on page 122
    * addition of `SILENT` and `EXECUTE` keywords, see Fig. 2 on page 122
    * addition of `ASINH` keyword to allow better visualisation of highly contrasted maps; see Figure 3 on page 123,
    * under certain circumstances, can process high resolution cut sky data sets without creating full sky dummy maps,
    * accept gzip compressed FITS files,
    * accept polarized cut sky maps,
    * accept multi-dimensional online arrays,
    * more robust `OUTLINE` option.
  - `median_filter`: bugs correction
  - `ud_grade`: more robust user interface
  - `change_polcconv`: new `/FORCE` keyword
  - `remove_dipole`: more accurate
  - `query_disc`: when the disc center is located at one of the poles, *only* the pixels overlapping with the disc are now returned.

- Miscellaneous
  - `mollcursor, gnomcursor...`: an X11 patch is given so that these routines work under Mac OS X 10.4 and 10.5.

alm_i2t

Location in HEALPix directory tree: src/idl/misc/alm_i2t.pro

This IDL function turns an indexed list of alm (as generated by fits2alm) into a tabular (real or complex) a(l,m) array for easier manipulation

FORMAT

IDL> alm_table=alm_i2t(Index, Alm_vec, [/COMPLEX, /HELP, LMAX=, MMAX=])

QUALIFIERS

Index	Integer vector of size ni containing the index i of the of $a_{\ell m}$ coefficients, related to $\{\ell, m\}$ by $i = \ell^2 + \ell + m + 1$
Alm_vec	Array of $a_{\ell m}$ coefficients, with dimension (ni, nalm [,nsig]) where ni = number of i indices nalm = 2 for real and imaginary parts of alm coefficients *or* 4 for above plus corresponding error values nsig = number of signals (usually 1 for any of T E B or 3 for T,E,B together)

KEYWORDS

/COMPLEX	if set, the output array is complex with dimensions (lmax+1, mmax+1, [nalm/2 , nsig]), otherwise, the array is real with dimensions (lmax+1, mmax+1, nalm [, nsig]). `lmax` and `mmax` are determined from input `Index` values, unless set otherwise by user.
/HELP	if set, prints out the help header and exits
LMAX=	`lmax` to be used in output array, regardless of value found in input index
MMAX=	`mmax` to be used in output array, regardless of value found in input index

DESCRIPTION

alm_i2t returns a real or complex array, containing the $a_{\ell m}$ with $0 \leq \ell \leq \ell_{\max}$ and $0 \leq m \leq m_{\max}$. The negative m are therefore ignored.

RELATED ROUTINES

This section lists the routines related to **alm_i2t**.

idl	version 6.4 or more is necessary to run alm_i2t.
alm_t2i	turns tabular alm's such as those generated by alm_i2t into indexed lists than can written to FITS files with alm2fits
alm2fits, fits2alm	routines to read and write $a_{\ell m}$ indexed lists from and to FITS files.

EXAMPLE:

```
fits2alm, i1, a1, 'alm1.fits'
ac1 = alm_i2t(i1, a1, /complex, lmax=100, mmax=100)

fits2alm, i2, a2, 'alm2.fits'
ac2 = alm_i2t(i2, a2, /complex, lmax=100, mmax=100)

ac = 0.9*ac1 + 0.1*ac2

alm_t2i, ac, i, a
alm2fits, i, a, 'almsum.fits'
```

The example above reads 2 sets of $a_{\ell m}$ from FITS files, puts the alm's with $(\ell, m) \leq 100$ in tabular arrays, and then make a weighted sum of the alm's. The resulting alm or put back into a indexed list in order to be written to FITS.

alm_t2i

Location in HEALPix directory tree: src/idl/misc/alm_t2i.pro

This IDL facility turns a tabular (real or complex) a(l,m) array into an indexed list of alm that can be written into a FITS file with alm2fits

FORMAT

IDL> alm_t2i, Alm_table, Index, Alm_vec, [/HELP, /MFIRST])

QUALIFIERS

Alm_table	Input real or complex array, containing all the $a^s_{\ell m}$ for ℓ in [0,$\ell_{\max}$] and m in [0,$m_{\max}$] (and s in [0,$s_{\max}$] if applicable) if REAL it has 3 (or 4) dimensions, if COMPLEX is has 2 (or 3) dimensions
Index	Output integer vector of size ni containing the index i of the of $a_{\ell m}$ coefficients, related to $\{\ell, m\}$ by $i = \ell^2 + \ell + m + 1$
Alm_vec	Output array of $a_{\ell m}$ coefficients, with dimension (ni, 2 [,$s_{\max}+1$]) where ni = number of i indices 2 for real and imaginary parts of alm coefficients $s_{\max}+1$ = number of signals (usually 1 for any of T E B or 3 for T,E,B together)

KEYWORDS

/HELP	if set, prints out the help header and exits
/MFIRST	if set, the input array is a(m,l) instead of a(l,m)

DESCRIPTION

alm_t2i turns a real or complex tabular array of a(l,m) (or a(m,l) is MFIRST is set) into a real list of $a_{\ell m}$ (with the real and imaginary parts separated) and its index $i = \ell^2 + \ell + m + 1$. The unphysical $m > \ell$ elements of the input table are dropped from the output list.

RELATED ROUTINES

This section lists the routines related to **alm_t2i**.

idl	version 6.4 or more is necessary to run alm_t2i.
alm_i2t	this function is complementary to alm_t2i and turns an indexed list of alm (as generated by fits2alm) into a tabular (real or complex) a(l,m) array for easier manipulation
alm2fits, fits2alm	routines to read and write $a_{\ell m}$ indexed lists from and to FITS files.

EXAMPLE:

See alm_i2t example

alm2fits

Location in HEALPix directory tree: src/idl/fits/alm2fits.pro

This IDL routine provides a means to write spherical harmonic coefficients (and optional errors) and their index label to a FITS file. Each signal is written to a separate binary table extension. The routine also writes header information if required. The facility is primarily designed to allow the user to write a FITS files containing constraints for a constrained realisation performed by the **HEALPix** facility **synfast**.

FORMAT

IDL> ALM2FITS, index, alm_array, fitsfile, [HDR=, /HELP, XHDR=]

QUALIFIERS

index — Long array containing the index for the corresponding array of alm coefficients (and erralm if required). The index i is related to ℓ, m by the relation
$i = \ell^2 + \ell + m + 1$

alm_array — Real array of alm coefficients written to the file. This has dimension (nl,nalm,nsig) – corresponding to
nl = number of l,m indices
nalm = 2 for real and imaginary parts of alm coefficients or 4 for above plus corresponding error values
nsig = number of signals to be written (1 for any of T E B or 3 if ALL to be written). Each signal is stored in a separate extension.

fitsfile — String containing the name of the file to be written.

KEYWORDS

HDR = — String array containing the primary header to be written in the FITS file.

/HELP	If set, the routine documentation header is shown and the routine exits
XHDR =	String array containing the extension header. If ALL signals are required, then each extension table is given this header. NOTE: optional header strings should NOT include the header keywords explicitly written by this routine.

DESCRIPTION

alm2fits writes the input alm coefficients (and associated errors if required) into a FITS file. Each signal type is written as a separate binary table extension. Optional headers conforming to the FITS convention can also be written to the output file. All required FITS header keywords are automatically generated by the routine and should NOT be duplicated in the optional header inputs. The keywords EXTNAME and TTYPE* are now also automatically generated.

RELATED ROUTINES

This section lists the routines related to **alm2fits**.

idl	version 6.4 or more is necessary to run alm2fits.
fits2alm	provides the complimentary routine to read in alm coefficients from a FITS file.
alm_i2t, alm_t2i	these facilities turn indexed lists of $a_{\ell m}$ into 2D a(l,m) tables and back
lm2index	converts the $a_{\ell m}$ order and degree (ℓ, m) into the index $i = \ell^2 + \ell + m + 1$ required by alm2fits.
cl2fits	routine to write a power spectrum into a FITS file.
fits2cl	routine to read/compute $C(\ell)$ power spectra from a file containing $C(\ell)$ or $a_{\ell m}$ coefficients
alteralm	utilises the output file generated by alm2fits.
synfast	utilises the output file generated by alm2fits.

EXAMPLE:

`alm2fits, index, alm, 'alm.fits', HDR = hdr, XHDR = xhdr`

alm2fits writes the coefficients stored in the variable `alm` to the output FITS file `alm.fits` with optional headers passed by the string variables `hdr` and `xhdr`.

ang2vec

Location in HEALPix directory tree: src/idl/toolkit/ang2vec.pro

This IDL facility convert the position angles of points on the sphere into their 3D position vectors.

FORMAT

IDL> ANG2VEC, Theta, Phi, Vector[, ASTRO=]

QUALIFIERS

Theta — input: scalar or vector,
colatitude in radians measured southward from north pole (in [0,π]).
If ASTRO is set, Theta is the latitude in degrees measured northward from the equator (in [-90, 90]).

Phi — input: scalar or vector of same size as Theta,
longitude in radians measured eastward (in [0, 2π]).
If ASTRO is set, it is the longitude in degree measured eastward (in [0,360]).

Vector — output : array,
three dimensional cartesian position vector (x, y, z) normalised to unity. The north pole is $(0, 0, 1)$. The coordinates are ordered as follows $x(0), \ldots, x(n-1)$, $y(0), \ldots, y(n-1)$, $z(0), \ldots, z(n-1)$

KEYWORDS

ASTRO= — if set Theta and Phi are the latitude and longitude in degrees instead of the colatitude and longitude in radians.

DESCRIPTION

ang2vec performs the geometrical transform from the position angles of points (θ, ϕ) into their position vectors (x, y, z): $x = \sin\theta\cos\phi$, $y = \sin\theta\sin\phi$, $z = \cos\theta$

RELATED ROUTINES

This section lists the routines related to **ang2vec**.

idl	version 6.4 or more is necessary to run ang2vec.
pix2xxx, ...	conversion between vector or angles and pixel index
vec2ang	conversion from position vectors to angles

EXAMPLE:

```
lat = -45 ; latitude in degrees
long = 120 ; longitude in degrees
ang2vec, lat, lon, /astro, vec
```

will return in `vec` the 3D cartesian position vector of the point of latitude -45 deg and longitude 120 deg

angulardistance

Location in HEALPix directory tree: src/idl/toolkit/angulardistance.pro

This IDL facility computes the angular distance (in RADIANS) between pairs of vectors.

FORMAT

IDL> distance=angulardistance(V, W, [/HELP])

QUALIFIERS

V — 3D-vector (of shape (3) or (1,3)) or list of n 3D-vectors (of shape (n,3))

W — 3D-vector (of shape (3) or (1,3)) or list of n 3D-vectors (of shape (n,3))
It is **not** necessary for `V` and `W` vectors to be normalised to 1 upon calling the function
If `V` (and/or `W`) has the form (n,3,4) (like the pixel *corners* returned by pix2vec_*), it should be preprocessed with `V = reform( transpose(V, [0,2,1]), n_elements(V)/3, 3)` before being passed to angulardistance.

KEYWORDS

/HELP — if set, prints out the help header and exits

DESCRIPTION

After renormalizing the vectors, angulardistance computes the angular distance using $\cos^{-1}(\mathbf{V}.\mathbf{W})$ in general, or $2\sin^{-1}\left(||\mathbf{V}-\mathbf{W}||\right)/2$ when $\mathbf{V}$ and $\mathbf{W}$ are almost aligned.
If $\mathbf{V}$ (resp. $\mathbf{W}$) is a single vector, while $\mathbf{W}$ (resp. $\mathbf{V}$) is a list of vectors, then the result is a list of distances $d_i = \mathrm{dist}(\mathbf{V}, \mathbf{W}_i)$ (resp. $d_i = \mathrm{dist}(\mathbf{V}_i, \mathbf{W})$).
If both $\mathbf{V}$ and $\mathbf{W}$ are lists of vector *of the same length*, then the result is a list of distances $d_i = \mathrm{dist}(\mathbf{V}_i, \mathbf{W}_i)$.

RELATED ROUTINES

This section lists the routines related to **angulardistance**.

idl — version 6.4 or more is necessary to run angulardistance.

EXAMPLE:

```
nside=8
pix2vec_ring, nside, lindgen(nside2npix(nside)), vpix
mollview, angulardistance( vpix, [1,1,1])
```

will plot the angular distance between the Healpix pixels center for $N_{\rm side} = 8$, and the vector $(x, y, z) = (1, 1, 1)/\sqrt{3}$

azeqview

Location in HEALPix directory tree: src/idl/visu/azeqview.pro

This IDL facility provides a means to visualise an azimuthal equidistant projection of **HEALPix** and COBE Quad-Cube maps in an IDL environment. It also offers the possibility to generate GIF, JPEG, PDF, PNG and Postscript color-coded images of the projected map. The projected (but not color-coded) data can also be output in FITS files and IDL arrays.

FORMAT

IDL> AZEQVIEW, File [, Select] [, ASINH=, BAD_COLOR=, BG_COLOR=, CHARSIZE=, CHARTHICK=, COLT=, COORD=, /CROP, CUSTOMIZE=, DEFAULT_SETTINGS=, EXECUTE=, FACTOR=, FG_COLOR=, FITS=, /FLIP, GAL_CUT=, GIF=, GLSIZE=, GRATICULE=, /HALF_SKY, HBOUND=, /HELP, /HIST_EQUAL, HXSIZE=, IGLSIZE=, IGRATICULE=, JPEG=, LATEX=, /LOG, MAP_OUT=, MAX=, MIN=, /NESTED, /NO_DIPOLE, /NO_MONOPOLE, /NOBAR, /NOLABELS, /NOPOSITION, OFFSET=, OUTLINE=, PDF=, PFONTS=, PNG=, POLARIZATION=, /PREVIEW, PS=, PXSIZE=, PYSIZE=, RESO_ARCMIN=, RETAIN=, ROT=, /SAVE, /SHADED, /SILENT, SILHOUETTE=, STAGGER=, SUBTITLE=, TITLEPLOT=, TRANSPARENT=, TRUECOLORS=, UNITS=, WINDOW=, XPOS=, YPOS=]

QUALIFIERS

For a full list of qualifiers see mollview

KEYWORDS

For a full list of keywords see mollview

DESCRIPTION

azeqview reads in a **HEALPix** sky map in FITS format and generates an azimuthal equidistant projection of it, that can be visualized on the screen or exported in a GIF, JPEG, PNG, PDF or Postscript file. azeqview allows the selection of the coordinate system, map size, color table, color bar inclusion, linear, log, hybrid or histogram equalised color scaling, maximum and minimum range for the plot, plot-title *etc.* It also allows the representation of the polarization field.

RELATED ROUTINES

This section lists the routines related to **azeqview**.

	see mollview
hpx2dm	turns Healpix maps into DomeMaster images using azeqview.

beam2bl

Location in HEALPix directory tree: src/idl/misc/beam2bl.pro

This IDL facility computes a transfer (or window) function $b(\ell)$ for a circular beam profile $b(\theta)$.

FORMAT

IDL> bl=beam2bl(beam, theta, lmax, [/ARCMIN , /DEGREES, /HELP, /RADIANS])

QUALIFIERS

beam	input beam profile $b(\theta)$
theta	angles θ (in arcmin, degrees or radians) at which the input beam $b(\theta)$ is defined
lmax	maximum multipole on which the output $b(\ell)$ is to be computed

KEYWORDS

/ARCMIN	if set, θ is in arcmin
/DEGREES	if set, θ is in degrees
/HELP	if set, prints out the help header and exits
/RADIANS	if set, θ is in radians

DESCRIPTION

Since the SH Transform of an arbitrary beam is

$$b_{\ell m} = \int d\mathbf{r}\; b(\mathbf{r})\; Y^*_{\ell m}(\mathbf{r}) \tag{1}$$

then, for a circular beam

$$\begin{aligned} b(\ell) &= b_{\ell 0}\sqrt{\frac{4\pi}{2\ell+1}} \\ &= \int b(\theta) P_\ell(\theta)\sin(\theta)\; d\theta\; 2\pi \end{aligned} \tag{2}$$

where P_ℓ is the Legendre Polynomial, $b(\ell)$ is the beam window (or transfer) function returned by beam2bl and $b(\theta)$ is the beam radial profile expected as input of beam2bl.
IDL's routine `INT_TABULATED` is used to perform the integration.

RELATED ROUTINES

This section lists the routines related to **beam2bl**.

idl	version 6.4 or more is necessary to run beam2bl.
bl2beam	facility to perform the inverse transform to beam2bl.
bl2fits	facility to write a $b(\ell)$ window function into a FITS file.
fits2cl	facility to read a $b(\ell)$ window function from a FITS file

EXAMPLE:

```
bl = gaussbeam(15.d0, 4000, 1)
theta = dindgen(4000)/100.
beam = bl2beam(bl, theta, /arcmin)
bl1 = beam2bl(beam, theta, 4000, /arcmin)
plot, bl1-bl
```

the example above generates a beam window function (defined for all ℓ in $\{0,\ldots,4000\}$) for a 15arcmin-FWHM gaussian beam, computes the beam profile for angles in $[0, 40]$ arcmin, computes back the beam window function from the beam profile and finally plots the difference between the beam window functions.

bin_llcl

Location in HEALPix directory tree: src/idl/misc/bin_llcl.pro

This IDL facility provides a means to bin an angular power spectrum into arbitrary bins.

FORMAT

IDL> BIN_LLCL, Llcl_in, Bin, L_out, Llcl_out, [Dllcl, DELTAL=, /FLATTEN, /HELP, /UNIFORM]

QUALIFIERS

Llcl_in — 1D vector: **input** power spectrum (given for each l starting at 0).

Bin — **input**: binning in l to be applied,
–either a scalar interpreted as the step size of a regular binning, the first bins are then {0, `bin` - 1},{`bin`, 2`bin`-1}, ...
–or a 1D vector, interpreted as the lower bound of each bin, ie the first bins are {bin[0],bin[1]-1}, {bin[1], bin[2]-1}, ...

L_out — contains on **output** the center of each bin l_b.

Llcl_out — contains on **output** the binned power spectrum $C(b)$, ie the (weighted) average of the input $C(l)$ over each bin.

Dllcl — **optional**, contains on **output** a rough estimate of the rms of the binned C(l) for a full sky observation $C(b)\sqrt{2/((2l_b+1)\Delta l_b)}$

DELTAL= — **optional**, contains on **output** the size of each bin $\Delta l(b)$

KEYWORDS

/FLATTEN — if set, the $C(l)$ is internally multiplied by $l(l+1)/2\pi$ before being binned.
By default, the input `Llcl_in` is binned as is.

/HELP	if set, an extended help is printed and the code exits.
/UNIFORM	if set, the $C(l)$ in each bin is given the same weight. By default a weight $\propto 2l+1$ is used (inverse cosmic variance weighting). Note that this weighting affects `Llcl_out` but not `L_out`.

DESCRIPTION

bin_llcl bins the input power spectrum (as is, or after flattening by a ł(ł+1)/2π factor) according to an arbitrary binning scheme defined by the user. Different weighting scheme (uniform or inverse variance) can be applied inside the bins.

RELATED ROUTINES

This section lists the routines related to **bin_llcl**.

idl	version 6.4 or more is necessary to run bin_llcl.
fits2cl	facility to read a power spectrum from a FITS file.

EXAMPLE:

```
init_healpix
fits2cl, cl, !healpix.directory+'/test/cl.fits', multipoles=l
fl = l*(l+1) / (2.  * !pi)
bin_llcl, fl*cl[*,0], 10, lb, bbcb, /uniform
plot, l, fl*cl[*,0]
oplot, lb, bbcb, psym = 4
```

Read a power spectrum, bin it with a binsize of 10 and a uniform weighting, and overplot the input spectrum and its binned version.

bl2beam

Location in HEALPix directory tree: src/idl/misc/bl2beam.pro

This IDL facility computes a circular beam profile $b(\theta)$ from its transfer (or window) function $b(\ell)$.

FORMAT

IDL> beam=bl2beam(bl, theta, [/ARCMIN , /DEGREES, /HELP, /RADIANS])

QUALIFIERS

bl	input $b(\ell)$ window function of beam (defined for all integer multipoles l starting at 0)
theta	angles θ (in arcmin, degrees or radians) at which the output beam $b(\theta)$ is to be computed.

KEYWORDS

/ARCMIN	if set, θ is in arcmin
/DEGREES	if set, θ is in degrees
/HELP	if set, prints out the help header and exits
/RADIANS	if set, θ is in radians

DESCRIPTION

Since an arbitrary beam is related to its SH Transform via

$$b(\mathbf{r}) = \sum_{\ell m} b_{\ell m} Y_{\ell m}(\mathbf{r}), \tag{3}$$

a circular beam has a radial profile (as returned by bl2beam)

$$b(\theta) = \sum_{\ell} b(\ell) P_{\ell}(\theta) \frac{2\ell + 1}{4\pi}, \tag{4}$$

where P_l is Legendre Polynomial and

$$b(\ell) = b_{\ell 0} \sqrt{\frac{4\pi}{2\ell + 1}} \tag{5}$$

is the beam window (or transfer) function, expected as input to bl2beam.

RELATED ROUTINES

This section lists the routines related to **bl2beam**.

idl	version 6.4 or more is necessary to run bl2beam.
beam2bl	facility to perform the inverse transform to bl2beam.
bl2fits	facility to write a $b(\ell)$ window function into a FITS file.
fits2cl	facility to read a $b(\ell)$ window function from a FITS file

EXAMPLE:

```
bl = gaussbeam(15.d0, 4000, 1)
theta = dindgen(3000)/100.
beam = bl2beam(bl, theta, /arcmin)
plot, theta, beam
```

the example above generates a beam window function (defined for all l in $\{0, \ldots, 4000\}$) for a 15arcmin-FWHM gaussian beam, computes the beam profile for angles in $[0, 30]$ arcmin and then plots it.

bl2fits

Location in HEALPix directory tree: src/idl/fits/bl2fits.pro

This IDL facility provides a means to write into a FITS file as an ascii table extension a (beam) window function $B(\ell)$. Adds additional headers if required. The facility is primarily intended to allow the user to write an arbitrary window function into a FITS file in the correct format to be ingested by the **HEALPix** simulation facilities `synfast`, `isynfast`, and others (see "Beam window function files" in the **HEALPix** Fortran Facilities document).

FORMAT

IDL> BL2FITS, bl_array, fitsfile, [HDR = , /HELP, XHDR =]

QUALIFIERS

bl_array	real or double array of Bl coefficients to be written to file. This has dimension (lmax+1,n) with $1 \leq n \leq 3$, given in the sequence T E B.
fitsfile	String containing the name of the file to be written.

KEYWORDS

HDR=	String array containing the (non-trivial) primary header for the FITS file.
/HELP	If set, a help message is printed out, no file is written
XHDR=	String array containing the (non-trivial) extension header for the FITS file.

DESCRIPTION

bl2fits writes the input $B(\ell)$ coefficients into a FITS file containing an ascii table extension. Optional headers conforming to the FITS convention can also be written to the output file. All required FITS header keywords (like SIMPLE, BITPIX, ...) are automatically generated by the routine and should NOT be duplicated in the optional header inputs (they would be ignored anyway). The one/two/three column(s) are automatically named `TEMPERATURE`, `GRAD`, `CURL` respectively. If the window function is provided in a double precision array, the output format will automatically feature more decimal places.

RELATED ROUTINES

This section lists the routines related to **bl2fits**.

idl	version 6.4 or more is necessary to run bl2fits.
fits2cl	provides the complimentary routine to read in a window function or power spectrum from a FITS file.
synfast	utilises the output file generated by bl2fits(option `beam_file`).

EXAMPLE:

```
beam1 = gaussbeam(10., 2000, 1)
beam2 = gaussbeam(15., 2000, 1)
beam = (beam1 + beam2) / 2.
bl2fits, beam, 'beam.fits'
```

bl2fits writes the beam window function stored in the variable `beam` (=Legendre transform of a circular beam) into the output FITS file `beam.fits`.

cartcursor

Location in HEALPix directory tree: src/idl/visu/cartcursor.pro

This IDL facility provides a point-and-click interface for finding the astronomical location, value and pixel index of the pixels nearest to the pointed position on a cartesian projection of a **HEALPix** map.

FORMAT

IDL> CARTCURSOR, [cursor_type=, file_out=]

QUALIFIERS

see mollcursor

DESCRIPTION

cartcursor should be called immediately after cartview. It gives the longitude, latitude, map value and pixel number corresponding to the cursor position in the window containing the map generated by orthview. For more details, or in case of problems under **Mac OS X**, see mollcursor.

RELATED ROUTINES

This section lists the routines related to **cartcursor**.

see mollcursor

EXAMPLE:

```
cartcursor
```

After cartview has read in a map and generated its cartesian projection, cartcursor is run to determine the position and flux of bright synchrotron sources, for example.

cartview

Location in HEALPix directory tree: src/idl/visu/cartview.pro

This IDL facility provides a means to visualise a cartesian (or equirectangular) projection (where the longitude and latitude are treated as the cartesian abscissa and ordinate) of **HEALPix** and COBE Quad-Cube maps in an IDL environment. It also offers the possibility to generate GIF, JPEG, PDF, PNG and Postscript color-coded images of the projected map. The projected (but not color-coded) data can also be output in FITS files and IDL arrays.

FORMAT

IDL> CARTVIEW, File [, Select] [, ASINH=, BAD_COLOR=, BG_COLOR=, CHARSIZE=, CHARTHICK=, COLT=, COORD=, /CROP, CUSTOMIZE=, DEFAULT_SETTINGS=, EXECUTE=, FACTOR=, FG_COLOR=, FITS=, /FLIP, GAL_CUT=, GIF=, GLSIZE=, GRATICULE=, /HALF_SKY, HBOUND=, /HELP, /HIST_EQUAL, HXSIZE=, IGLSIZE=, IGRATICULE=, JPEG=, LATEX=, /LOG, MAP_OUT=, MAX=, MIN=, /NESTED, /NO_DIPOLE, /NO_MONOPOLE, /NOBAR, /NOLABELS, /NOPOSITION, OFFSET=, OUTLINE=, PDF=, PFONTS=, PNG=, POLARIZATION=, /PREVIEW, PS=, PXSIZE=, PYSIZE=, RESO_ARCMIN=, RETAIN=, ROT=, /SAVE, /SHADED, /SILENT, SILHOUETTE=, STAGGER=, SUBTITLE=, TITLEPLOT=, TRANSPARENT=, TRUECOLORS=, UNITS=, WINDOW=, XPOS=, YPOS=]

QUALIFIERS

For a full list of qualifiers see mollview

KEYWORDS

For a full list of keywords see mollview

DESCRIPTION

cartview reads in a **HEALPix** sky map in FITS format and generates a cartesian projection of it, that can be visualized on the screen or exported in a GIF, JPEG, PNG, PDF or Postscript file. cartview allows the selection of the coordinate system, map size, color table, color bar inclusion, linear, log, hybrid or histogram equalised color scaling, maximum and minimum range for the plot, plot-title *etc.* It also allows the representation of the polarization field.

RELATED ROUTINES

This section lists the routines related to **cartview**.

see mollview

EXAMPLE:

```
map = findgen(48)
triangle= create_struct('coord','G','ra',[0,80,0],'dec',[40,45,65])
cartview,map,/online,res=45,graticule=[45,30],rot=[10,20,30],pysize=250,$
   title='Cartesian cylindrical (full sky)',subtitle='cartview', $
   outline=triangle
```

makes a cartesian cylindrical projection of map (see Figure 1a on page 122) after an arbitrary rotation, with a graticule grid (with a 45^o step in longitude and 30^o in latitude) and an arbitrary triangular outline

change_polcconv

Location in HEALPix directory tree: src/idl/fits/change_polcconv.pro

This IDL facility changes the coordinate convention in FITS file containing a polarised sky map. The main effect is to change the sign of the U Stokes parameter, and add/update the `POLCCONV` FITS header keyword with either `COSMO` or `IAU` value.
See note on POLCCONV in The **HEALPix** Primer

FORMAT

IDL> CHANGE_POLCCONV, File_In, File_Out, [/I2C|/C2I|/C2C|/I2I], [/FORCE]

QUALIFIERS

File_In — name of a FITS file to be read

File_Out — name of a FITS file to be written, after modification of the polarisation coordinate convention, if applicable. It must be different from File_In

KEYWORDS

One and only one among I2C, C2I, C2C and I2I must be set.

/I2C — changes from IAU to COSMO coordinate convention
-if POLCCONV is not found or found with value 'IAU', or FORCE is set, it is added/replaced with value 'COSMO', and the sign of the U Stokes parameter map is changed;
-if POLCCONV already has value 'COSMO' and FORCE is NOT set, File_In is copied unchanged into File_Out.

/C2I — changes from COSMO to IAU coordinate convention
-if POLCCONV is not found or found with value 'COSMO', or FORCE is set, it is added/replaced with value 'IAU', and the sign of the U Stokes parameter map is changed;
-if POLCCONV already has value 'IAU', and

FORCE is NOT set, File_In is copied unchanged into File_Out.

/C2C — does NOT change coordinate system
-if POLCCONV is found with value 'IAU', and FORCE is NOT set, program will issue error message and no file is written;
-in all other cases POLCCONV is set/added with value 'COSMO' in File_Out, but data is NOT changed.

/I2I — does NOT change coordinate system
-if POLCCONV is found with value 'COSMO', and FORCE is NOT set, program will issue error message and no file is written;
-in all other cases POLCCONV is set/added with value 'IAU' in File_Out, but data is NOT changed.

/FORCE — if set, the value of `POLCCONV` read from File_In FITS header is ignored. The sign of U is swapped (if used with /C2I or /I2C), and/or the File_Out FITS keyword is updated to IAU (if used with /I2I or /C2I) or to COSMO (if used with /C2C or /I2C).

DESCRIPTION

This routine will change the sign of the U Stokes parameters (and related quantities, such as the TU and QU cross-correlations) and update the `POLCCONV` FITS keyword where applicable. The recognised formats are:
- standard **HEALPix** full sky polarised format,
- cut sky **HEALPix** polarised format,
- WMAP 9-year release polarised `*_iqumap_*` and `*_iqusmap_*` formats,
- Planck `*_SkyMap_*` and `*_CMB_IQU*` formats

RELATED ROUTINES

This section lists the routines related to **change_polcconv** .

idl — version 6.4 or more is necessary to run change_polcconv

write_fits_cut4 — This **HEALPix** IDL facility can be used to write

	a (polarised or unpolarised) cut sky map into a FITS file.
read_fits_cut4	This **HEALPix** IDL facility can be used to read a (polarised or unpolarised) cut sky map from a FITS file.
write_tqu	This **HEALPix** IDL facility can be used to write a polarised full sky map (with either the standard Healpix format or the WMAP 2nd year format) into a FITS file
read_tqu	This **HEALPix** IDL facility can be used to read a polarised cut sky map from a FITS file

EXAMPLE:

```
change_polcconv, 'map_cosmo.fits','map_iau.fits',/c2i
```

Modify the file 'map_cosmo.fits', which was using the 'COSMO' convention for polarisation coordinate convention into 'map_iau.fits' which uses the 'IAU' convention

cl2fits

Location in HEALPix directory tree: src/idl/fits/cl2fits.pro

This IDL facility provides a means to write into a FITS file as an ascii table extension the power spectrum coefficients passed to the routine. Adds additional headers if required. The facility is primarily intended to allow the user to write a theoretical power spectrum into a FITS file in the correct format to be ingested by the **HEALPix** simulation facility **synfast**.

FORMAT

IDL> CL2FITS, cl_array, fitsfile, [HDR=, /HELP, XHDR=, /CMBFAST, UNITS=]

QUALIFIERS

cl_array — real or double array of Cl coefficients to be written to file. This has dimension either (lmax+1,9) given in the sequence T E B TxE TxB ExB ExT BxT BxE **or** (lmax+1,6) given in the sequence T E B TxE TxB ExB **or** (lmax+1,4) given in the sequence T E B TxE **or** (lmax+1) for T alone. The convention for the power spectrum is that it is not normalised by the Harrison-Zeldovich (flat) spectrum.

fitsfile — String containing the name of the file to be written.

KEYWORDS

HDR= — String array containing the (non-trivial) primary header for the FITS file.

/HELP — If set, a help message is printed out, no file is written

XHDR= — String array containing the (non-trivial) extension header for the FITS file.

/CMBFAST — if set, the routine will add the keyword 'POLNORM = CMBFAST' in the FITS header, meaning that the polarization power spectra have the

same convention as CMBFAST (and Healpix 1.2). If this keyword is not present in the input FITS file, `synfast` will issue a warning when simulating a polarization map from that power spectrum, but no attempt to renormalize the power spectra will be made. To actually perform the renormalization, see convert_oldhpx2cmbfast

UNITS= String scalar containing units of power spectrum (eg, uKˆ2, Kelvin**2, ...), to be put in keywords 'TUNIT*' of the extension header. If provided, will override the values present in XHDR (if any).

NOTE: optional header strings should NOT include the header keywords explicitly written by this routine.

DESCRIPTION

cl2fits writes the input power spectrum coefficients into a FITS file containing an ascii table extension. Optional headers conforming to the FITS convention can also be written to the output file. All required FITS header keywords (like SIMPLE, BITPIX, ...) are automatically generated by the routine and should NOT be duplicated in the optional header inputs (they would be ignored anyway). The one/four/six/nine column(s) are automatically named `TEMPERATURE`, `GRAD`, `CURL`, `TG`, `TC`, `GC`, `GT`, `CT` and `CG` respectively. If the power spectrum is provided in a double precision array, the output format will automatically feature more decimal places. The current implementation is much faster than the one available in Healpix 1.10 thanks to replacing an internal loop by vector operations.

RELATED ROUTINES

This section lists the routines related to **cl2fits**.

idl version 6.4 or more is necessary to run cl2fits.

fits2cl provides the complimentary routine to read in a power spectrum from a FITS file.

convert_oldhpx2cmbfast convert an existing power spectrum FITS file from the polarization convention used in Healpix 1.1 to the one used in Healpix 1.2 (and CMBFAST).

bl2fits	facility to write a window function into a FITS file.
fits2alm, alm2fits	routines to read and write $a_{\ell m}$ coefficients
synfast	utilises the output file generated by cl2fits.

EXAMPLE:

```
cl2fits, pwrsp, 'spectrum.fits', HDR = hdr, XHDR = xhdr
```

cl2fits writes the power spectrum stored in the variable `pwrsp` to the output FITS file `spectrum.fits` with optional headers passed by the string variables `hdr` and `xhdr`.

convert_oldhpx2cmbfast

Location in HEALPix directory tree: src/idl/fits/convert_oldhpx2cmbfast.pro

This IDL facility provides a means to change the normalization of polarization power spectra in a FITS file from Healpix 1.1 convention to Healpix 1.2 (which is the same as CMBFAST).

FORMAT

IDL> CONVERT_OLDHPX2CMBFAST, file_in, [file_out, NO_RENORM=]

QUALIFIERS

file_in — String containing the name of the FITS file with the power spectra to be read.

file_out — (OPTIONAL) String containing the name of the file to be written after renormalization. If absent, `file_in` will be used for output

KEYWORDS

NO_RENORM= — if set, the renormalization is not done. but the keyword POLNORM = CMBFAST is added to the FITS header (useful if the FITS file is already in CMBFAST format).

DESCRIPTION

convert_oldhpx2cmbfast does the conversion from the polarization normalisation used in **HEALPix** 1.1 to the one used in **HEALPix** 1.2 (see the Healpix primer document). A keyword POLNORM = CMBFAST is added to the header to keep track of which files have been renormalized. If this keyword is not present in the input FITS file, **synfast** will issue a warning when simulating a polarization map from that power spectrum, but no attempt to renormalize the power spectra will be made.

RELATED ROUTINES

This section lists the routines related to **convert_oldhpx2cmbfast**.

idl	version 6.4 or more is necessary to run convert_oldhpx2cmbfast.
cl2fits	provides the a routine to write a power spectrum to a FITS file.
fits2cl	provides the complimentary routine to read in a power spectrum from a FITS file.
synfast	utilises the output file generated by convert_oldhpx2cmbfast.

EXAMPLE:

```
convert_oldhpx2cmbfast, 'cl_flat.fits'
```

convert_oldhpx2cmbfast will renormalize the polarization power spectra read from 'cl_flat.fits', and write them in the same file.

euler_matrix_new

Location in HEALPix directory tree: src/idl/misc/euler_matrix_new.pro

This IDL facility provides a means to generate a 3D rotation Euler matrix parametrized by three angles and three axes of rotation.

FORMAT

IDL> matrix = EULER_MATRIX_NEW(a1, a2, a3 [,DEG=, HELP=, X=, Y=, ZYX=])

QUALIFIERS

matrix	a 3x3 array containing the Euler matrix
a1	input, float scalar, angle of the first rotation, expressed in radians, unless DEG (see below) is set
a2	angle of the second rotation, same units as a1
a3	angle of the third rotation, same units as a1

KEYWORDS

DEG=	if set, the angles are in degrees instead of radians
HELP=	if set, the routine prints its documentation header and exits
X=	if set, uses the classical mechanics convention (ZXZ): rotation a1 around original Z axis, rotation a2 around intermediate X axis, rotation a3 around final Z axis (see Goldstein (1951) for more details). *Equivalent to:* rotation a3 around Z axis, rotation a2 around initial (unrotated) X axis, rotation a1 around initial (unrotated) Z axis. (**default:** this convention is used)
Y=	if set, uses the quantum mechanics convention (ZYZ): rotation a1 around original Z axis,

rotation a2 around intermediate Y axis,
rotation a3 around final Z axis.
Equivalent to:
rotation a3 around Z axis,
rotation a2 around initial (unrotated) Y axis,
rotation a1 around initial (unrotated) Z axis.

ZYX= if set, uses the aeronautics convention (ZYX):
rotation a1 around original Z axis,
rotation a2 around intermediate Y axis,
rotation a3 around final X axis.
Equivalent to:
rotation a3 around X axis,
rotation a2 around initial (unrotated) Y axis,
rotation a1 around initial (unrotated) Z axis.

DESCRIPTION

euler_matrix_new allows the generation of a rotation Euler matrix. The user can choose the three Euler angles, and the three axes of rotation.
If `vec` is an N×3 array containing N 3D vectors,
`vecr = vec # euler_matrix_new(a1,a2,a3,/Y)`
will be the rotated vectors. Alternatively, rotate_coord can also be used to rotate `vec` into `vecr`.

This routine supersedes euler_matrix, which had inconsistent angle definitions. The relation between the two routines is as follows :
euler_matrix_new(a,b,c,/X) = euler_matrix(−a,−b,−c,/X)
= Transpose(euler_matrix(c, b, a,/X))
euler_matrix_new(a,b,c,/Y) = euler_matrix(−a, b,−c,/Y)
= Transpose(euler_matrix(c,−b, a,/Y))
euler_matrix_new(a,b,c,/Z) = euler_matrix(−a, b,−c,/Z)

RELATED ROUTINES

This section lists the routines related to **euler_matrix_new**.

idl version 6.4 or more is necessary to run euler_matrix_new.

rotate_coord apply a rotation to a set of position vectors and polarization Stokes parameters.

fits2alm

Location in HEALPix directory tree: src/idl/fits/fits2alm.pro

This IDL routine provides a means to read from a FITS file binary table extension(s) containing spherical harmonic coefficients $a_{\ell m}$ (and optional errors) and their index. Reads header information if required. The facility is intended to enable the user to read the output from the **HEALPix** facilities **anafast** and **synfast**.

FORMAT

IDL> FITS2ALM, index, alm_array, fitsfile, [signal, /HELP, HDR=, LMAX=, LMIN=, XHDR=]

QUALIFIERS

index	Long array containing the index for the corresponding array of $a_{\ell m}$ coefficients (and errors if required). The index i is related to (ℓ, m) by the relation $i = \ell^2 + \ell + m + 1$. This has dimension nl (see below).
alm_array	Real or double array of alm coefficients read from the file. This has dimension (nl,nalm,nsig) – corresponding to nl = number of (ℓ, m) indices nalm = 2 for real and imaginary parts of alm coefficients or 4 for above plus corresponding error values nsig = number of signals to be written (1 for any of T E B or 3 if ALL to be written). Each signal is stored in a separate extension.
fitsfile	String containing the name of the file to be read.
signal	String defining the signal coefficients to read Valid options: 'T', 'E', 'B' or 'ALL' (**default:** 'T').

KEYWORDS

HDR=	String array containing the primary header read from the FITS file.
/HELP	If set, the routine documentation header is shown and the routine exits
LMAX=	Largest ℓ multipole to be output
LMIN=	Smallest ℓ multipole to be output. If LMIN (resp. LMAX) is below (above) the range of l's present in the file, it will be silently ignored
XHDR=	String array containing the read extension header(s). If ALL signals are required, then the three extension headers are returned appended into one string array.

DESCRIPTION

fits2alm reads binary table extension(s) which contain the $a_{\ell m}$ coefficients (and associated errors if present) from a FITS file. FITS headers can also optionally be read from the input file.

RELATED ROUTINES

This section lists the routines related to **fits2alm**.

idl	version 6.4 or more is necessary to run fits2alm.
alm2fits	provides the complimentary routine to write $a_{\ell m}$ coefficients into a FITS file.
alm_i2t, alm_t2i	these facilities turn indexed lists of $a_{\ell m}$ into 2D a(l,m) tables and back
index2lm	converts the index $i = \ell^2 + \ell + m + 1$ returned by fits2alm into ℓ and m
lm2index	converts (ℓ, m) vectors into $i = \ell^2 + \ell + m + 1$
fits2cl	routine to read/compute $C(\ell)$ power spectra from a file containing $C(\ell)$ or $a_{\ell m}$ coefficients
ianafast, isynfast	IDL routine providing $a_{\ell m}$ coefficients file to be read by fits2alm.
alteralm, anafast, synfast	F90 facilities providing $a_{\ell m}$ coefficients file to be read by fits2alm.

EXAMPLE:

```
fits2alm, index, alm, 'alm.fits', HDR = hdr, XHDR = xhdr
```

fits2alm reads from the input FITS file `alm.fits` the $a_{\ell m}$ coefficients into the variable `alm` with optional headers passed by the string variables `hdr` and `xhdr`. Upon return `index` will contain the value of $\ell^2 + \ell + m + 1$ for each $a_{\ell m}$ found in the file.

fits2cl

Location in HEALPix directory tree: src/idl/fits/fits2cl.pro

This IDL facility provides a means to read from a FITS file an ascii or binary table extension containing power spectrum ($C(\ell)$) or spherical harmonics ($a_{\ell m}$) coefficients, and returns the corresponding power spectrum ($C(\ell) = \sum_m a_{\ell m} a^*_{\ell m}/(2\ell + 1)$). Reads primary and extension headers if required. The facility is intended to enable the user to read the output from the **HEALPix** facility **anafast**.

FORMAT

IDL> fits2cl, cl_array, [fitsfile, EXTENSION= , HDR= , /HELP, /INTERACTIVE, LLFACTOR=, MULTIPOLES=, /PLANCK1=, /PLANCK2=, /PLANCK3=, /RSHOW, /SHOW, /SILENT=, /WMAP1=, /WMAP5=, /WMAP7=, XHDR=]

QUALIFIERS

cl_array — real array of C_ℓ coefficients read or computed from the file. The output dimension depends on the contents of the file. This has dimension either (lmax+1,9) given in the sequence T E B TxE TxB ExB ExT BxT BxE **or** (lmax+1,6) given in the sequence T E B TxE TxB ExB **or** (lmax+1,4) for T E B TxE **or** (lmax+1) for T alone.
The convention for the power spectrum is that it is not normalised by the Harrison-Zeldovich (flat) spectrum.

fitsfile — String containing the name of the FITS file to be read. The file contains either $C(\ell)$ power spectra or $a_{\ell m}$ coefficients. In either cases, $C(\ell)$ is returned. If `fitsfile` is not set, then `/PLANCK1`, `/PLANCK2`, `/PLANCK3`, `/WMAP1`, `/WMAP5` or `/WMAP7` must be set.

KEYWORDS

EXTENSION= extension unit to be read from FITS file: either its 0-based ID number (ie, 0 for first extension *after* primary array) or the case-insensitive value of its EXTNAME keyword.

HDR = String array containing on output the primary header read from the FITS file.

/HELP If set, produces an extended help message (using the doc_library IDL command).

/INTERACTIVE If set, the plots generated by `/SHOW` and `/RSHOW` options are produced using iPlot routine, allowing for interactive cropping, zooming and annotation of the plots. This requires IDL 6.4 or newer to work properly.

LLFACTOR = vector containing on output the factor $\ell(\ell+1)/2\pi$ which is often applied to $C(\ell)$ to flatten it for plotting purposes

MULTIPOLES = vector containing on output the multipoles ℓ for which the power spectra are provided. They are either
- read from the file (1st column in the Planck format),
- or generated by the routine (assuming that all multipoles from 0 to lmax included are provided).

/PLANCK1 If set, and `fitsfile` is not provided, then a Planck 2013+external data best fit model (!healpix.path.test+'planck2013ext_lcdm_cl_v1.fits' which matches !healpix.path.test+'cl_planck1.fits') defined up to lmax=4500, is read.
See !healpix.path.test+'README' for details

/PLANCK2 If set, and `fitsfile` is not provided, then a Planck 2015 data best fit model (!healpix.path.test+'planck2015_lcdm_cl_v2.fits' which matches !healpix.path.test+'cl_planck2.fits') defined up to lmax=4900, is read.
See !healpix.path.test+'README' for details

/PLANCK3 If set, and `fitsfile` is not provided, then a Planck 2018 data

best fit model (!healpix.path.test+-'planck2018_lcdm_cl_v3.fits' which matches !healpix.path.test+'cl_planck3.fits') defined up to lmax=5000, is read.
See !healpix.path.test+'README' for details

/RSHOW — If set, the raw power spectra $C(\ell)$ read from the file are plotted

/SHOW — If set, the rescaled power spectra $\ell(\ell+1)C(\ell)/2\pi$ are plotted

/SILENT — If set, no message is issued during normal execution

/WMAP1 — If set, and `fitsfile` is not provided, then one WMAP-1yr best fit model (!healpix.path.test+-'wmap_lcdm_pl_model_yr1_v1.fits' which currently matches !healpix.path.test+'cl.fits') defined up to lmax=3000, is read.
See !healpix.path.test+'README' for details

/WMAP5 — If set, and `fitsfile` is not provided, then one WMAP-5yr best fit model (!healpix.path.test+-'wmap_lcdm_sz_lens_wmap5_cl_v3.fits' which matches !healpix.path.test+'cl_wmap5.fits') defined up to lmax=2000, is read.
See !healpix.path.test+'README' for details

/WMAP7 — If set, and `fitsfile` is not provided, then one WMAP-7yr best fit model (!healpix.path.test+-'wmap_lcdm_sz_lens_wmap7_cl_v4.fits' which matches !healpix.path.test+'cl_wmap7.fits') defined up to lmax=3726, is read.
Note: As opposed to the other WMAP spectra mentionned above, it includes a non-vanishing B (or CURL) power spectrum induced by lensing of E (or GRAD) polarization.
See !healpix.path.test+'README' for details

XHDR = — String array containing on output the extension header read from the FITS file.

DESCRIPTION

fits2cl reads the power spectrum coefficients from a FITS file containing an ascii table extension. Descriptive headers conforming to the FITS convention can also be read from the input file.

RELATED ROUTINES

This section lists the routines related to **fits2cl**.

idl	version 6.4 or more is necessary to run fits2cl.
bin_llcl	facility to bin a spectrum read with fits2cl.
bl2fits	facility to write a window function into a FITS file.
cl2fits	provides the complimentary routine to write a power spectrum to a FITS file.
fits2alm, alm2fits	routines to read and write $a_{\ell m}$ coefficients
ianafast	IDL routine computing $C(\ell)$ files that can be read by fits2cl.
anafast	F90 facility computing $C(\ell)$ files that can be read by fits2cl.

EXAMPLE:

```
fits2cl, pwrsp, '$HEALPIX/test/cl.fits', $
           HDR=hdr, XHDR=xhdr, MULTI=l, LLFACT=fll
plot, l, powrsp[*,0]*fll
```

fits2cl reads a power spectrum $C(\ell)$ from the input FITS file `$HEALPIX/test/cl.fits` into the variable `pwrsp`, with optional headers passed by the string variables `hdr` and `xhdr`. The multipoles ℓ and factors $\ell(\ell+1)/2\pi$ are read into `l` and `fll` respectively. $\ell(\ell+1)C(\ell)/2\pi$ vs ℓ is then plotted.

gaussbeam

Location in HEALPix directory tree: src/idl/misc/gaussbeam.pro

This IDL facility provides the window function in ℓ space for a gaussian axisymmetric beam of given FWHM.

FORMAT

IDL> beam=GAUSSBEAM(Fwhm, Lmax [, Dim, HELP=])

QUALIFIERS

Fwhm	Full Width Half Maximum of the gaussian beam, in arcmin (scalar real)
Lmax	the window function is computed for the multipoles ℓ in {0,...,Lmax}
Dim	scalar integer, optional. If absent or set to 0 or 1, the output has size (Lmax+1) and is the temperature beam; if set to $2 \leq$ Dim ≤ 4 , the output has size (Lmax+1,Dim) and contains in that order : the TEMPERATURE beam, the GRAD/ELECTRIC polarization beam the CURL/MAGNETIC polarization beam the TEMPERATURE*GRAD beam
HELP=	if set, prints out the help header and exits

DESCRIPTION

gaussbeam computes the ℓ space window function of a gaussian beam of FWHM Fwhm. For a sky of underlying power spectrum $C(\ell)$ observed with beam of given FWHM, the measured power spectrum will be $C(\ell)_{\rm meas} = C(\ell)B(\ell)^2$ where $B(\ell)$ is given by gaussbeam(Fwhm,Lmax). The polarization beam is also provided (when Dim > 1) assuming a perfectly co-polarized beam (eg, Challinor et al 2000, astro-ph/0008228)

RELATED ROUTINES

This section lists the routines related to **gaussbeam**.

idl	version 6.4 or more is necessary to run gaussbeam
healpixwindow	computes the ℓ space window function associated with a **HEALPix** pixel size
synfast	f90 code to generate CMB maps of given power spectrum convolved with a gaussian beam
smoothing	f90 code to smooth existing **HEALPix** maps with a gaussian beam
anafast	f90 code to compute the power spectrum of a **HEALPix** sky map

EXAMPLE:

```
beam = gaussbeam(5.,1200)
```

beam contains the window function in {0,...,1200} of a gaussian beam of fwhm 5 arcmin

getdisc_ring

Location in HEALPix directory tree: src/idl/toolkit/getdisc_ring.pro

This routine is obsolete. Use query_disc instead.

getsize_fits

Location in HEALPix directory tree: src/idl/fits/getsize_fits.pro

This IDL function reads the number of maps and/or the pixel ordering of a FITS file containing a **HEALPix** map.

FORMAT

IDL> var = GETSIZE_FITS (File, [Nmaps=, Nside=, Mlpol=, Ordering=, Obs_Npix=, Type=, Header=, Extension=, /Help])

QUALIFIERS

File — name of a FITS file containing the **HEALPix** map(s).

var — contains on output the number of pixels stored in a map FITS file. Each pixel is counted only once (even if several information is stored on each of them, see nmaps). Depending on the data storage format, result may be :
– equal or smaller to the number Npix of Healpix pixels available over the sky for the given resolution (Npix = 12*nside*nside)
– equal or larger to the number of non blank pixels (obs_npix)

Nmaps= — contains on output the number of maps in the file

Nside= — contains on output the **HEALPix** resolution parameter $N_{\rm side}$

Mlpol= — contains on output the maximum multipole used to generate the map

Ordering= — contains on output the pixel ordering scheme: either 'RING' or 'NESTED'

Obs_Npix= — contains on output the number of non blanck pixels. It is set to -1 if it can not be determined from header

Type= — Healpix/FITS file type
<0 : file not found, or not valid
0 : image only fits file, deprecated Healpix format (var = $12N_{\rm side}^2$)
1 : ascii table, generally used for C(l) storage
2 : binary table : with implicit pixel indexing (full sky) (var = $12N_{\rm side}^2$)
3 : binary table : with explicit pixel indexing (generally cut sky) (var $\leq 12N_{\rm side}^2$)
999 : unable to determine the type

Header= contains on output the FITS extension header

Extension= extension unit to be read from FITS file: either its 0-based ID number (ie, 0 for first extension *after* primary array) or the case-insensitive value of its EXTNAME keyword.

KEYWORDS

HELP= if set, an extensive help is displayed and no file is read

DESCRIPTION

getsize_fits gets the number of pixels in a FITS file. If the file follows the **HEALPix** standard, the routine can also get the resolution parameter Nside, the ordering scheme, ..., and can determine the type of data set contained in the file.

RELATED ROUTINES

This section lists the routines related to **getsize_fits** .

idl — version 6.4 or more is necessary to run getsize_fits

read_fits_map — This **HEALPix** IDL facility can be used to read in maps written by getsize_fits .

sxaddpar — This IDL routine (included in **HEALPix** package) can be used to update or add FITS keywords to `Header`

reorder — This **HEALPix** IDL routine can be used to reorder a map from NESTED scheme to RING scheme and vice-versa.

write_fits_sb — routine to write multi-column binary FITS table

EXAMPLE:

```
npix = getsize_fits(!healpix.directory+'/test/map.fits', nside=nside, $
   mlpol=lmax, type=filetype)
print, npix, nside, lmax, filetype
```

should produce something like
196608 128 256 2
meaning that the map contained in that file has 196608 pixels, the resolution parameter is nside=128, the maximum multipole was 256, and this a full sky map (type 2).

gnomcursor

Location in HEALPix directory tree: src/idl/visu/gnomcursor.pro

This IDL facility provides a point-and-click interface for finding the astronomical location, value and pixel index of the pixels nearest to the pointed position on a gnomonic projection of a **HEALPix** map.

FORMAT

IDL> GNOMCURSOR, [cursor_type=, file_out=]

QUALIFIERS

see mollcursor

DESCRIPTION

gnomcursor should be called immediately after gnomview. It gives the longitude, latitude, map value and pixel number corresponding to the cursor position in the window containing the map generated by gnomview. For more details, or in case of problems under **Mac OS X**, see mollcursor.

RELATED ROUTINES

This section lists the routines related to **gnomcursor**.

see mollcursor

EXAMPLE:

```
gnomcursor
```

After gnomview has read in a map and generated its gnomonic projection, gnomcursor is run to determine the position and flux of bright synchrotron sources, for example.

gnomview

Location in HEALPix directory tree: src/idl/visu/gnomview.pro

This IDL facility provides a means to visualise a Gnomonic projection (radial projection onto a tangent plane) of **HEALPix** and COBE Quad-Cube maps in an IDL environment. It also offers the possibility to generate GIF, JPEG, PDF, PNG and Postscript color-coded images of the projected map. The projected (but not color-coded) data can also be output in FITS files and IDL arrays.

FORMAT

IDL> GNOMVIEW, File [, Select] [, ASINH=, BAD_COLOR=, BG_COLOR=, CHARSIZE=, CHARTHICK=, COLT=, COORD=, /CROP, CUSTOMIZE=, DEFAULT_SETTINGS=, EXECUTE=, FACTOR=, FG_COLOR=, FITS=, /FLIP, GAL_CUT=, GIF=, GLSIZE=, GRATICULE=, /HALF_SKY, HBOUND=, /HELP, /HIST_EQUAL, HXSIZE=, IGLSIZE=, IGRATICULE=, JPEG=, LATEX=, /LOG, MAP_OUT=, MAX=, MIN=, /NESTED, /NO_DIPOLE, /NO_MONOPOLE, /NOBAR, /NOLABELS, /NOPOSITION, OFFSET=, OUTLINE=, PDF=, PFONTS=, PNG=, POLARIZATION=, /PREVIEW, PS=, PXSIZE=, PYSIZE=, RESO_ARCMIN=, RETAIN=, ROT=, /SAVE, /SHADED, /SILENT, SILHOUETTE=, STAGGER=, SUBTITLE=, TITLEPLOT=, TRANSPARENT=, TRUECOLORS=, UNITS=, WINDOW=, XPOS=, YPOS=]

QUALIFIERS

For a full list of qualifiers see mollview

KEYWORDS

For a full list of keywords see mollview

DESCRIPTION

gnomview reads in a **HEALPix** sky map in FITS format and generates a gnomic (or gnomonic) projection of it, that can be visualized on the screen or exported in a GIF, JPEG, PNG, PDF or Postscript file. gnomview allows the selection of the coordinate system, map size, color table, color bar inclusion, linear, log, hybrid or histogram equalised color scaling, maximum and minimum range for the plot, plot-title *etc.* It also allows the representation of the polarization field.

RELATED ROUTINES

This section lists the routines related to **gnomview**.

see mollview

EXAMPLES: #1

```
gnomview, 'planck100GHZ-LFI.fits', rot=[160,-30], reso_arcmin=2., $
   pxsize = 500., $
   title='Simulated Planck LFI Sky Map at 100GHz', $
   min=-100,max=100
```

gnomview reads in the map 'planck100GHZ-LFI.fits' and generates an output image of the size of 500×500 screen pixels, with a resolution of 2 arcmin/screen pixel at the center. The temperature scale has been set to lie between ± 100, and the units will show as μK. The title 'Simulated Planck LFI Sky Map at 100GHz' has been appended to the image. The map is centered at (l =160, b =-30)

EXAMPLES: #2

```
map = findgen(48)
triangle= create_struct('coord','G','ra',[0,80,0],'dec',[40,45,65])
gnomview,map,/online,res=25,graticule=[45,30],rot=[10,20,30],$
   title='Gnomic projection',subtitle='gnomview', $
   outline=triangle
```

makes a gnomic projection of map (see Figure 1b on page 122) after an arbitrary rotation, with a graticule grid (with a 45^o step in longitude and 30^o in latitude) and an arbitrary triangular outline

healpix_doc

Location in HEALPix directory tree: src/idl/misc/healpix_doc.pro

This IDL facility displays HTML or PDF **HEALPix** documentation

FORMAT

IDL> healpix_doc, [HTML=| PDF=] [, HELP=, WHOLE=]

KEYWORDS

HELP= if set, an extensive help on healpix_doc is displayed.

HTML= if set, the **HEALPix** (IDL) HTML documentation is shown with a web browser. If the browser is already in use, a new tab is open.

PDF= if set, the **HEALPix** (IDL) PDF documentation is shown with a pdf viewer.
Either HTML or PDF must be set.

WHOLE= if set, the whole **HEALPix** documentation is accessible, not just the IDL related part.

DESCRIPTION

healpix_doc calls `Online_help` to open either the HTML or PDF **HEALPix** documentation. The browser and viewer used are those found by the `$IDL_DIR/bin/online_help_html` and `$IDL_DIR/bin/online_help_pdf` scripts respectively. The content of the `!healpix` system variable is used to determine the documentation path.

RELATED ROUTINES

This section lists the routines related to **healpix_doc**.

idl version 6.4 or more is necessary to run healpix_doc.

!HEALPIX	IDL system variable used by healpix_doc to locate the documentation.

EXAMPLES: #1

```
healpix_doc, /html, /whole
```

will open the whole **HEALPix** HTML documentation in a web browser.

EXAMPLES: #2

```
healpix_doc, /pdf
```

will open the IDL related **HEALPix** PDF documentation.

healpixwindow

Location in HEALPix directory tree: **src/idl/misc/healpixwindow.pro**

This IDL facility provides the window function in ℓ associated with the Healpix pixel of resolution Nside.

FORMAT

IDL> wpix=HEALPIXWINDOW(Nside [, Dim, Directory])

QUALIFIERS

Nside	resolution parameter
Wpix	the pixel window function, computed for the multipoles ℓ in {0,...,4Nside}
Dim	scalar integer, optional. If absent or set to 0 or 1, the output has size (4 Nside+1) and is the temperature window function; if set to $2 \leq$ Dim ≤ 4 , the output has size (4 Nside+1,Dim) and contains in that order : the TEMPERATURE window function, the GRAD/ELECTRIC polarization one the CURL/MAGNETIC polarization one the TEMPERATURE*GRAD one.
Directory	directory in which the precomputed pixel window file is looked for. (**default:** $)HEALPIX/data/

DESCRIPTION

healpixwindow computes the ℓ space window function due to the finite size of the **HEALPix** pixels. The typical size of a pixel (square root of its uniform surface area) is $\sqrt{3/\pi}\ 3600/N_{\rm side}$ arcmin. If a unpixelated sky has a power spectrum $C(\ell)$, the same sky pixelated with a resolution parameter Nside will have the power spectrum $C(\ell)_{\rm pix} = C(\ell)W(\ell)^2$ where $W(\ell)$ is given by healpixwindow(Nside). The polarized pixel window function is also provided (when Dim > 1). This routine reads some FITS files located in the subdirectory `data/` of the **HEALPix** distribution, unless the keyword `Directory` is set otherwise.

RELATED ROUTINES

This section lists the routines related to **healpixwindow**.

idl	version 6.4 or more is necessary to run healpixwindow
gaussbeam	computes the ℓ space window function associated with a gaussian beam
synfast	f90 code to generate CMB maps of given power spectrum at a given resolution (=pixel size)
anafast	f90 code to compute the power spectrum of a **HEALPix** sky map

EXAMPLE:

```
wpix = healpixwindow(256)
```

wpix contains the window function in {0,...,1024} of the **HEALPix** pixel with resolution parameter 256 (pixel size of 13.7 arcmin)

help_st

Location in HEALPix directory tree: src/idl/misc/help_st.pro

This IDL facility provides some HELP-like information on any IDL variable, and especially on sub-structures.

FORMAT

IDL> help_st, Var

QUALIFIERS

Var	IDL variable, of any kind

DESCRIPTION

If `Var` is an IDL structure, help_st does a recursive `HELP,/STRUCTURES` on `Var` and each of its substructure, otherwise it does the equivalent of `HELP, Var` (see respectively Examples #1 and #2 below)

RELATED ROUTINES

This section lists the routines related to **help_st**.

idl	version 6.4 or more is necessary to run help_st.

EXAMPLES: #1

```
init_healpix ; make sure that !healpix is defined
help, /structure, !healpix
help_st, !healpix
```

the example above compares the output of `help,/structures` which only describes the top structure:

```
** Structure <151cef8>, 7 tags, length=528, data length=524, refs=2:
  VERSION     STRING   '3.40'
  DATE        STRING   '2018-01-01'
  DIRECTORY   STRING   '/home/user/Healpix'
  PATH        STRUCT   -> <Anonymous> Array[1]
  NSIDE       LONG     Array[30]
  BAD_VALUE   FLOAT    -1.63750e+30
  COMMENT     STRING   Array[15]
```

and `help_st`, which describes each sub-structure:

```
** Structure <151cef8>, 7 tags, length=528, data length=524, refs=2:
  .VERSION         STRING   '3.40'
  .DATE            STRING   '2018-01-01'
  .DIRECTORY       STRING   '/home/user/Healpix'
  .PATH.BIN.CXX    STRING   '/home/user/Healpix/src/cxx/generic_gcc/bin/'
  .PATH.BIN.F90    STRING   '/home/user/Healpix/bin/'
  .PATH.DATA       STRING   '/home/user/Healpix/data/'
  .PATH.DOC.HTML   STRING   '/home/user/Healpix/doc/html/'
  .PATH.DOC.PDF    STRING   '/home/user/Healpix/doc/pdf/'
  .PATH.SRC        STRING   '/home/user/Healpix/src/'
  .PATH.TEST       STRING   '/home/user/Healpix/test/'
  .NSIDE           LONG     Array[30]
  .BAD_VALUE       FLOAT    -1.63750e+30
  .COMMENT         STRING   Array[15]
```

EXAMPLES: #2

```
a=0
help,a+1
help_st, a+1
```

will print out

```
<Expression>       INT        =        1
A+1        INT        =        1
```

hpx2dm

Location in HEALPix directory tree: src/idl/visu/hpx2dm.pro

This IDL facility provides a means to turn a **HEALPix** data set into a DomeMaster compliant image (azimuthal equidistant projection of the half-sphere in a PNG or lossless JPEG file) that can be projected on a planetarium. See eg http://fulldome.ryanwyatt.net/fulldome_domemasterSpec_v05.pdf

FORMAT IDL> hpx2dm, File, [Select,] [/HELP, JPEG=, PNG=, PREVIEW=, PXSIZE=, + most of azeqview keywords...]

QUALIFIERS

File — Required
name of a FITS file containing the **HEALPix** map in an extension or in the image field,
or name of an *online* variable (either array or structure) containing the **HEALPix** map (See note below);
if Save is set : name of an IDL saveset file containing the **HEALPix** map stored under the variable `data`
(**default:** none)

Select — Optional
column of the BIN FITS table to be plotted, can be either
– a name : value given in TTYPEi of the FITS file
NOT case sensitive and can be truncated,
(only letters, digits and underscore are valid)
– an integer : number i of the column containing the data, starting with 1 (also valid if `File` is an online array)
(**default:** 1 for full sky maps, 'SIGNAL' column for FITS files containing cut sky maps)

KEYWORDS

JPEG= — name of the output *lossless* JPEG file

PNG= — name of the output PNG file

/PREVIEW — if set, the output JPEG or PNG file will be previewed

/HELP — Prints out the documentation header

PXSIZE= — number of pixels in each dimension of the square output image

/ASINH, COLT=, COORD=, FACTOR=, /FLIP, HBOUND=, /HIST_EQUAL, /LOG, MAX=, MIN=, /NESTED, OFFSET=, /QUADCUBE, ROT=, SAVE=, /SILENT, TRUECOLORS= — those keywords have the same meaning as in azeqview and mollview

DESCRIPTION

hpx2dm reads in a **HEALPix** sky map in FITS format or from a memory array and generates a PNG or JPEG file containing a DomeMaster compliant map (azimuthal equidistant projection of the half-sky).

RELATED ROUTINES

This section lists the routines related to **hpx2dm**.

azeqview	performs Azimuthal Equidistant projection required by hpx2dm.
hpx2gs	turns Healpix maps into GoogleEarth, GoogleSky or Oculus VR compatible images

hpx2gs

Location in HEALPix directory tree: src/idl/visu/hpx2gs.pro

This IDL facility provides a means to turn a **HEALPix** map into a image that can be visualized with Google Earth or Google Skyas well as with Oculus VR headsets.

FORMAT IDL> hpx2gs, File, [Select,] [COORD_IN=, /HELP, KML=, PNG=, RESO_ARCMIN=, SUBTITLE=, TITLEPLOT=,+ most of cartview keywords...]

QUALIFIERS

File — Required
name of a FITS file containing the **HEALPix** map in an extension or in the image field,
or name of an *online* variable (either array or structure) containing the **HEALPix** map (See note below);
if Save is set : name of an IDL saveset file containing the **HEALPix** map stored under the variable `data`
(**default:** none)

Select — Optional
column of the BIN FITS table to be plotted, can be either
– a name : value given in TTYPEi of the FITS file
NOT case sensitive and can be truncated,
(only letters, digits and underscore are valid)
– an integer : number i of the column containing the data, starting with 1 (also valid if `File` is an online array)
(**default:** 1 for full sky maps, 'SIGNAL' column for FITS files containing cut sky maps)

KEYWORDS

COORD_IN= — 1-character scalar, describing the input data coordinate system:
either 'C' or 'Q' : Celestial2000 = eQuatorial,
'E' : Ecliptic,
'G' : Galactic.
If set, it will over-ride the coordinates read from the FITS file header (when applicable). In absence of information, the input coordinates is assumed to be celestial.
The data will be rotated so that the output coordinates are Celestial, as expected by Google Sky

/HELP — Prints out the documentation header

KML= — Name of the KML file to be created (if the `.kml` suffix is missing, it will be added automatically). Used only by Google Earth and Google Sky. (**default:** `'hpx2googlesky.kml'`)

PNG= — Name of the PNG overlay file to be created. Only to be used if you want the filename to be different from the default ((**default:** same as KML file, with a `.png` suffix instead of `.kml`))

RESO_ARCMIN= Pixel angular size in arcmin (at the equator) of the cartesian map generated (**default:** 30)

SUBTITLE= information on the data, will appear in KML file `GroundOverlay description` field

TITLEPLOT= information on the data, will appear in KML file `GroundOverlay name` field

/ASINH, COLT=, FACTOR=, /FLIP, GLSIZE=, GRATICULE=, HBOUND=, /HIST_EQUAL, IGLSIZE=, IGRATICULE=, /LOG, MAX=, MIN=, /NESTED, OFFSET=, OUTLINE=, POLARIZATION=, /PREVIEW, /QUADCUBE, SAVE=, /SILENT, TRUECOLORS= those keywords have the same meaning as in cartview and mollview

DESCRIPTION

hpx2gs reads in a **HEALPix** sky map in FITS format or from a memory array and generates a cartesian (equirectangular) projection of it in a PNG file, as well as a Google Sky compatible KML file. Missing or unobserved pixels in the input data will be totally 'transparent' in the output file.

RELATED ROUTINES

This section lists the routines related to **hpx2gs**.

see cartview

hpx2dm turns Healpix maps into DomeMaster images

EXAMPLE:

```
map = findgen(48)
hpx2gs, map, kml='my_map.kml',title='my map in Google'
```

produces in `my_map.kml` and in `my_map.png` an image of the input map that can be seen with Google Sky. To do so, start GoogleEarth or GoogleSky and open `my_map.kml`. Under Mac-OSX, simply type `open my_map.kml` on the command line.

ialteralm

Location in HEALPix directory tree: src/idl/interfaces/ialteralm.pro

This IDL facility provides an interface to F90 'alteralm' facility. This program can be used to modify a set of $a_{\ell m}$ spherical harmonics coefficients, as those extracted by ianafast or simulated by isynfast, before they are used as constraints on a isynfast run. Currently the alterations possible are

- rotation (using Wigner matrices) of the $a_{\ell m}$ from the input coordinate system to any other standard astrophysical coordinate system. The resulting $a_{\ell m}$ can be used with e.g. synfast to generate a map in the new coordinate system.
- removal of the pixel and beam window functions of the input $a_{\ell m}$ (corresponding to the pixel size and beam shape of the map from which they were extracted) and implementation of an arbitrary pixel and beam window function.

$$a_{\ell m}^{\rm OUT} = a_{\ell m}^{\rm IN} \frac{B^{\rm OUT}(\ell) P^{\rm OUT}(\ell)}{B^{\rm IN}(\ell) P^{\rm IN}(\ell)}, \qquad (6)$$

where $P(\ell)$ is the pixel window function, and $B(\ell)$ is the beam window function (assuming a circular beam) or any other ℓ space filter (eg, Wiener filter). For an infinitely small pixel (or beam) one would have $P(\ell) = 1$ (resp. $B(\ell) = 1$) for any ℓ.

FORMAT IDL> IALTERALM, alm_in, alm_out, [beam_file_in, beam_file_out, binpath=, coord_in, coord_out, epoch_in, epoch_out, fwhm_arcmin_in, fwhm_arcmin_out, /help, keep_tmp_files=, lmax_out, nlmax_out, nside_in, nside_out, nsmax_in, nsmax_out, /silent, tmpdir=, windowfile_in, winfiledir_in, windowfile_out, winfiledir_out]

QUALIFIERS

alm_in	required input: input $a_{\ell m}$, must be a FITS file
alm_out	required output: output $a_{\ell m}$, must be a FITS file

KEYWORDS

binpath=	full path to back-end routine (**default:** $HEXE/alteralm, then $HEALPIX/bin/alteralm) – a binpath starting with / (or \), or $ is interpreted as absolute – a binpath starting with ./ is interpreted as relative to current directory – all other binpaths are relative to $HEALPIX
beam_file_in=	Beam window function of input $a_{\ell m}$, either a FITS file or an array (see "Beam window function files" section in the **HEALPix** Fortran Facilities document). If present, will override `fwhm_arcmin_in` (**default:** value of BEAM_LEG keyword read from `alm_in`)
beam_file_out=	Beam window function of output alm, either a FITS file or an array (see `beam_file_in`. If present and non-empty, will override `fwhm_arcmin_out` (**default:** " (empty string, no beam window applied))
coord_in=	Astrophysical coordinates system used to compute input $a_{\ell m}$. Case-insensitive single letter code. Valid choices are 'g','G' = Galactic, 'e','E' = Ecliptic, 'c','q','C','Q' = Celestial/eQuatorial. (**default:** value of COORDSYS keyword read from `alm_in`)
coord_out=	Astrophysical coordinates system of output alm. (**default:** `coord_in`)
epoch_in=	Astronomical epoch of input coordinates (`coord_in`) (**default:** 2000.0)
epoch_out=	Astronomical epoch of output coordinates (`coord_out`) (**default:** same as `epoch_in`)
fwhm_arcmin_in=	Full Width Half-Maximum in arcmin of Gaussian beam applied to map from which are obtained in-

	put $a_{\ell m}$. (**default:** value of FWHM keyword in `alm_in`)
fwhm_arcmin_out=	FWHM in arcmin to be applied to output alm. (**default:** `fwhm_arcmin_in`)
/help	if set, prints extended help
/keep_tmp_files	if set, temporary files are not discarded at the end of the run
lmax_out=, nlmax_out=	maximum multipole of output alm
nside_in=, nsmax_in=	HEALPix resolution parameter of map from which were computed input $a_{\ell m}$ (**default:** determined from `alm_in`)
nside_out=,nsmax_out=	HEALPix resolution parameter Nside whose window function will be applied to output alm. Could be set to 0 for infinitely small pixels (no window) (**default:** same as input `nsmax_in`)
/silent	if set, works silently
tmpdir=	directory in which are written temporary files (**default:** IDL_TMPDIR (see IDL documentation))
windowfile_in=	FITS file containing pixel window for nside_in (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing
winfiledir_in=	directory where windowfile_in is to be found (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing
windowfile_out=	FITS file containing pixel window for nside_out (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing
winfiledir_out=	directory where windowfile_out is to be found (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing

DESCRIPTION

ialteralm is an interface to 'alteralm' F90 facility. It requires some disk space on which to write the parameter file and the other temporary files. Most data can be provided/generated as an external FITS file, or as a memory array.

RELATED ROUTINES

This section lists the routines related to **ialteralm**.

idl	version 6.4 or more is necessary to run ialteralm.
alteralm	F90 facility called by ialteralm.
ianafast	IDL Interface to F90 anafast and C++ anafast_cxx
iprocess_mask	IDL Interface to F90 process_mask
ismoothing	IDL Interface to F90 smoothing
isynfast	IDL Interface to F90 synfast

EXAMPLE:

```
ialteralm, !healpix.path.test+'alm.fits', '/tmp/alm_equat.fits', $
coord_in='g',coord_out='q'
isynfast, 0, alm_in='/tmp/alm_equat.fits', '/tmp/map_equat.fits'
mollview,'/tmp/map_equat.fits',1
mollview,'/tmp/map_equat.fits',2
```

This example script reads the test (polarised) $a_{\ell m}$ located in `$HEALPIX/test/alm.fits` and rotates them from Galactic to Equatorial coordinates, it then synthetizes a map out of those, and finally plots its I and Q Stokes components (in Equatorial coordinates)

ianafast

Location in HEALPix directory tree: src/idl/interfaces/ianafast.pro

This IDL facility provides an interface to 'anafast' F90 and 'anafast_cxx' C++ facilities. It can be used to produce the Spherical Harmonics coefficients ($a_{\ell m}$ of a **HEALPix** map (or pair of maps) and/or the resulting auto (or cross) power spectra $C(\ell)$.

FORMAT

IDL> IANAFAST, map1_in[, cl_out, alm1_out=, alm2_out=, binpath=, cxx=, double=, help=, healpix_data=, iter_order=, keep_tmp_files=, map2_in=, mask-file=, nested=, nlmax=, nmmax=, order-ing=, plmfile=, polarisation=, regression=, ring=, show_cl=, simul_type=, silent=, theta_cut_deg=, tmpdir=, weighted=, won=, w8file=, w8dir=]

QUALIFIERS

map1_in — required input: 1st input map, can be a FITS file, or a memory array containing the map to analyze

cl_out — optional output: auto or cross power spectrum $C(\ell)$, can be a FITS file or a memory array

KEYWORDS

alm1_out= — output alm of 1st map, must be a FITS file (**default:** alm not kept)

alm2_out= — output alm of 2nd map (if any, must be a FITS file) (**default:** alm not kept)

binpath= — full path to back-end routine (**default:** $HEXE/anafast, then

	$HEALPIX/bin/anafast or $HEALPIX-/src/cxx/$HEALPIX_TARGET/bin/anafast_-cxx, then $HEALPIX/src/cxx/generic_gcc-/bin/anafast_cxx if cxx is set) – a binpath starting with / (or \), or $ is interpreted as absolute – a binpath starting with ./ is interpreted as relative to current directory – all other binpaths are relative to $HEALPIX
/cxx	if set, the C++ back-end anafast_cxx is invoked instead of F90 anafast, AND the parameter file is written accordingly
/double	if set, I/O is done in double precision (**default:** single precision I/O)
/help	if set, prints extended help
healpix_data=	same as w8dir
iter_order=	order of iteration in the analysis (**default:** 0)
/keep_tmp_files	if set, temporary files are not discarded at the end of the run
map2_in=	2nd input map (FITS file or array), if provided, Cl_out will contain the cross power spectra of the 2 maps (**default:** no 2nd map)
maskfile=	pixel mask (FITS file or array) (**default:** no mask)
/nested=	if set, signals that *all* maps and mask read online are in NESTED scheme (does not apply to FITS file), see also /ring and Ordering
nlmax=	maximum multipole of analysis, *required* for C++ anafast_cxx, optional for F90 anafast
nmmax=	maximum degree m, only valid for C++ anafast_cxx (**default:** nlmax)
ordering=	either 'RING' or 'NESTED', ordering of online maps and masks, see /nested and /ring
plmfile=	FITS file containing precomputed Spherical Harmonics (deprecated) (**default:** no file)
/polarisation	if set analyze temperature + polarization (same as simul_type = 2)
regression=	0, 1 or 2, regress out best fit monopole and/or dipole before alm analysis (**default:** 0, analyze raw map)
/ring	see /nested and ordering above

/show_cl	if set, and `cl_out` is defined, the produced $\ell(\ell+1)C(\ell)/2\pi$ will be plotted
simul_type=	1 or 2, analyze temperature only or temperature + polarization
/silent	if set, works silently
theta_cut_deg=	cut around the equatorial plane
tmpdir=	directory in which are written temporary files (**default:** IDL_TMPDIR (see IDL documentation))
weighted=	same as won (**default:** see won)
won=	if set to 0, no weighting applied, if set to 1, a ring-based quadrature weighting scheme is applied, if set to 2, a pixel-based quadrature weighting scheme is applied. (**default:** 1: apply ring-based weighting)
w8file=	In F90: FITS file containing weights (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing In C++ (/cxx flag): must be set to full path of weight file, consistent with value of won (or weighted)
w8dir=	In F90 only: directory where the weights are to be found (**default:** determined automatically by back-end routine)

DESCRIPTION

ianafast is an interface to 'anafast' F90 and 'anafast_cxx' C++ facilities. It requires some disk space on which to write the parameter file and the other temporary files. Most data can be provided/generated as an external FITS file, or as a memory array.

RELATED ROUTINES

This section lists the routines related to **ianafast**.

idl	version 6.4 or more is necessary to run ianafast.
anafast	F90 facility called by ianafast.
anafast_cxx	C++ called by ianafast.

ialteralm	IDL Interface to F90 alteralm
iprocess_mask	IDL Interface to F90 process_mask
ismoothing	IDL Interface to F90 smoothing
isynfast	IDL Interface to F90 synfast

EXAMPLE:

```
whitenoise = randomn(seed, nside2npix(256))
ianafast, whitenoise, cl, /ring, /silent
plot, cl[*,0]
```

will plot the power spectrum of a white noise map

index2lm

Location in HEALPix directory tree: src/idl/misc/index2lm.pro

This IDL routine provides a means to convert the $a_{\ell m}$ index $i = \ell^2 + \ell + m + 1$ (as returned by eg the fits2alm routine) into ℓ and m.

FORMAT

IDL> INDEX2LM, index, l, m

QUALIFIERS

index	Long array containing on INPUT the index $i = \ell^2 + \ell + m + 1$.
l	Long array containing on OUTPUT the order ℓ. It has the same size as `index`.
m	Long array containing on OUTPUT the degree m. It has the same size as `index`.

DESCRIPTION

index2lm converts $i = \ell^2 + \ell + m + 1$ into (ℓ, m). Note that the index i is only defined for $0 \leq |m| \leq \ell$.

RELATED ROUTINES

This section lists the routines related to **index2lm**.

idl	version 6.4 or more is necessary to run index2lm.
fits2alm	reads a FITS file containing $a_{\ell m}$ values.
alm2fits	writes $a_{\ell m}$ values into a FITS file.
lm2index	routine complementary to index2lm: converts (ℓ, m) into $i = \ell^2 + \ell + m + 1$.

EXAMPLE:

```
index2lm, index, l, m
```

will return in `l` and `m` the order ℓ and degree m such that `index` $= \ell^2 + \ell + m + 1$

init_healpix

Location in HEALPix directory tree: src/idl/misc/init_healpix.pro

This IDL facility creates an IDL system variable (!HEALPIX) containing various **HEALPix** related quantities

FORMAT

IDL> INIT_HEALPIX [,VERBOSE=]

KEYWORDS

VERBOSE= if set, turn on the verbose mode, giving a short description of the variables just created.

DESCRIPTION

init_healpix defines the IDL system variable and structure !HEALPIX containing several quantities and character string necessary to **HEALPix** , eg : allowed resolution parameters Nside, full path to package directory, package version...

RELATED ROUTINES

This section lists the routines related to **init_healpix**.

idl version 6.4 or more is necessary to run init_healpix.

!HEALPIX IDL system variable defined by init_healpix.

EXAMPLES: #1

```
init_healpix,/verbose
```

init_healpix will create the system variable !Healpix, and give a short description of the tags available, as shown below

```
Initializing !HEALPIX system variable
This system variable contains some information on Healpix :
!HEALPIX.VERSION = current version number,
!HEALPIX.DATE = date of release,
!HEALPIX.DIRECTORY = directory containing Healpix package,
!HEALPIX.PATH = structure containing:
!HEALPIX.PATH.BIN = structure containing binary path :
!HEALPIX.PATH.BIN.CXX = C++
!HEALPIX.PATH.BIN.F90 = Fortran90
!HEALPIX.PATH.DATA = path to data subdirectory,
!HEALPIX.PATH.DOC = path to doc subdirectories (.html, .pdf),
!HEALPIX.PATH.SRC = path to src subdirectory,
!HEALPIX.PATH.TEST = path to test subdirectory,
!HEALPIX.NSIDE = list of all valid values of Nside parameter,
!HEALPIX.BAD_VALUE = value of flag given to missing pixels in
FITS files,
!HEALPIX.COMMENT = this description.
```

EXAMPLES: #2

```
help, !healpix, /structure
```

will print the content of the !Healpix system structure.

iprocess_mask

Location in HEALPix directory tree: src/idl/interfaces/iprocess_mask.pro

This IDL facility provides an interface to F90 'process_mask' facility. For a given input binary mask, it can determine the angular distance in Radians of each valid (1 valued) pixel to the closest invalid (0 valued) pixel, with the option of ignoring small clusters of invalid pixels. The distance map can then be used to generate an apodized mask.

FORMAT

IDL> IPROCESS_MASK, mask_in, distance_map,[binpath=, filled_mask=, /help, hole_arcmin2=, hole_pixels=, keep_tmp_files=, /nested, ordering=, /ring, /silent, tmpdir=]

QUALIFIERS

mask_in — required input: input binary mask. It can be a FITS file, or a memory array containing the mask to process.

distance_map — optional output: double precision angular distance map in Radians. It can be a FITS file, or a memory array. It will have the same ordering as the input mask.

KEYWORDS

binpath= — full path to back-end routine (**default:** $HEXE/process_mask, then $HEALPIX/bin/process_mask)
– a binpath starting with / (or \), or $ is interpreted as absolute
– a binpath starting with ./ is interpreted as relative to current directory
– all other binpaths are relative to $HEALPIX

filled_mask=	optional output mask with holes smaller than `hole_arcmin2` or `hole_pixels` filled in. Will have the same ordering as the input mask
/help	if set, prints extended help
hole_arcmin2	Minimal size (in arcmin^2) of invalid regions to be kept (can be used together with `hole_pixels`, the result will be the largest of the two). (**default:** 0.0)
hole_pixels	Minimal size (in pixels) of invalid regions to be kept (can be used together with `hole_arcmin2`, the result will be the largest of the two). (**default:** 0)
/keep_tmp_files	if set, temporary files are not discarded at the end of the run
/nested	if set, signals that the mask read online is in NESTED scheme (does not apply to FITS file), see also `/ring` and `Ordering`
ordering=	either 'RING' or 'NESTED', ordering of online mask, see `/ring` and `/nested`
/ring	see `/nested` and `Ordering` above
/silent	if set, works silently
tmpdir=	directory in which are written temporary files (**default:** IDL_TMPDIR (see IDL documentation))

DESCRIPTION

iprocess_mask is an interface to 'process_mask' F90 facility. It requires some disk space on which to write the parameter file and the other temporary files. Most data can be provided/generated as an external FITS file, or as a memory array.

RELATED ROUTINES

This section lists the routines related to **iprocess_mask**.

idl	version 6.4 or more is necessary to run iprocess_mask.
process_mask	F90 facility called by iprocess_mask.
ialteralm	IDL Interface to F90 alteralm

ianafast	IDL Interface to F90 anafast and C++ anafast_cxx
ismoothing	IDL Interface to F90 smoothing
isynfast	IDL Interface to F90 synfast

EXAMPLE:

```
npix = nside2npix(256)
mask = replicate(1, npix) & mask[randomu(seed,100)*npix] = 0
iprocess_mask, mask, distance, /ring, /silent
mollview, distance
```

A binary mask in which 100 randomly located pixels are 0-valued (=invalid) is generated. Then the distance (in Radians) of the valid pixels to the closest invalid pixels is computed and plotted.

ismoothing

Location in HEALPix directory tree: src/idl/interfaces/ismoothing.pro

This IDL facility provides an interface to F90 'smoothing' facility. It can be used to smooth a **HEALPix** map by an arbitrary circular 'beam' defined by its Legendre window function (or its FWHM if it is assumed Gaussian)

FORMAT

IDL> ISMOOTHING, map1_in, map2_out,[beam_file=, binpath=, /double, fwhm_arcmin=, /help, iter_order=, keep_tmp_files=, lmax=, nlmax=, /nested, ordering=, plmfile=, regression=, /ring, simul_type=, /silent, theta_cut_deg=, tmpdir=, /won, w8file=, w8dir=]

QUALIFIERS

map1_in — required input: input map, can be a FITS file, or a memory array containing the map to smooth

map2_out — required output: output smoothed map, can be a FITS file, or a memory array

KEYWORDS

beam_file= — beam window function, either a FITS file or an array (see "Beam window function files" section in the **HEALPix** Fortran Facilities document).

binpath= — full path to back-end routine (**default:** $HEXE/smoothing, then $HEALPIX/bin/smoothing)
– a binpath starting with / (or \), or $ is interpreted as absolute
– a binpath starting with ./ is interpreted as relative to current directory

	– all other binpaths are relative to $HEALPIX
/double	if set, I/O is done in double precision (**default:** single precision I/O)
fwhm_arcmin=	gaussian beam Full Width Half Maximum in arcminutes (**default:** 0)
/help	if set, prints extended help
iter_order=	order of iteration in the analysis (**default:** 0)
/keep_tmp_files	if set, temporary files are not discarded at the end of the run
lmax=, nlmax=	maximum multipole of smoothing (**default:** determined by back-end routine (ie, smoothing))
/nested	if set, signals that *all* maps and mask read online are in NESTED scheme (does not apply to FITS file), `/ring` and `Ordering`
ordering=	either 'RING' or 'NESTED', ordering of online maps and masks, see `/ring` and `/nested`
plmfile=	FITS file containing precomputed Spherical Harmonics (deprecated) (**default:** no file)
regression=	0, 1 or 2, regress out best fit monopole and/or dipole before alm analysis (**default:** 0, analyze raw map)
/ring	see `/nested` and `Ordering` above
simul_type=	1 or 2, analyze temperature only or temperature + polarization
/silent	if set, works silently
theta_cut_deg=	cut around the equatorial plane
tmpdir=	directory in which are written temporary files (**default:** IDL_TMPDIR (see IDL documentation))
won=	if set to 0, no weighting applied, if set to 1, a ring-based quadrature weighting scheme is applied, if set to 2, a pixel-based quadrature weighting scheme is applied. (**default:** 1: apply ring-based weighting)
w8file=	FITS file containing weights (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing

w8dir= directory where the weights are to be found (**default:** determined automatically by back-end routine)

DESCRIPTION

ismoothing is an interface to 'smoothing' F90 facility. It requires some disk space on which to write the parameter file and the other temporary files. Most data can be provided/generated as an external FITS file, or as a memory array.

RELATED ROUTINES

This section lists the routines related to **ismoothing**.

idl	version 6.4 or more is necessary to run ismoothing.
smoothing	F90 facility called by ismoothing.
beam2bl	This IDL facility computes a transfer (or window) function $b(l)$ (such as the ones required by ismoothing) for a given circular beam profile $b(\theta)$
ialteralm	IDL Interface to F90 alteralm
ianafast	IDL Interface to F90 anafast and C++ anafast_cxx
iprocess_mask	IDL Interface to F90 process_mask
isynfast	IDL Interface to F90 synfast

EXAMPLE:

```
whitenoise = randomn(seed, nside2npix(256))
ismoothing, whitenoise, rednoise, fwhm=120, /ring, simul=1,/silent
mollview, whitenoise,title='White noise'
mollview, rednoise, title='Smoothed white Noise'
```

will generate and plot a white noise map and its smoothed version

isynfast

Location in HEALPix directory tree: src/idl/interfaces/isynfast.pro

This IDL facility provides an interface to F90 'synfast' facility. It can be used to generate sky maps and/or $a_{\ell m}$ from power spectra ($C(\ell)$), synthesize maps from $a_{\ell m}$ or simulate maps from $C(\ell)$ and constraining $a_{\ell m}$.

FORMAT

IDL> ISYNFAST, cl_in[, map_out, alm_in=, alm_out=, apply_windows=, beam_file=, binpath=, double=, fwhm_arcmin=, help=, iseed=, keep_tmp_files=, lmax=, nlmax=, nside=, nsmax=, plmfile=, simul_type=, silent=, tmpdir=, windowfile=, winfiledir=]

QUALIFIERS

cl_in	input power spectrum, can be a FITS file, or a memory array containing the $C(\ell)$, used to generate a map or a set of gaussian alm If empty quotes (") or a zero (0) are provided, it will be interpreted as "No input C(l)", in which case some input alm's (alm_in) are required.
map_out	optional output: *RING ordered* map synthetised from the power spectrum or from constraining alm

KEYWORDS

alm_in=	optional input (constraining) alm (must be a FITS file) (**default:** no alm)
alm_out=	contains on output the effective alm (must be a FITS file)
/apply_windows	if set, beam and pixel windows are applied to input alm_in (if any)
beam_file=	beam window function, either a FITS file or an

	array (see "Beam window function files" section in the **HEALPix** Fortran Facilities document)
binpath=	full path to back-end routine (**default:** $HEXE/synfast, then $HEALPIX/bin/synfast) – a binpath starting with / (or \), or $ is interpreted as absolute – a binpath starting with ./ is interpreted as relative to current directory – all other binpaths are relative to $HEALPIX
/double	if set, I/O is done in double precision (**default:** single precision I/O)
fwhm_arcmin=	gaussian beam FWHM in arcmin (**default:** 0)
/help	if set, prints extended help
iseed=	integer seed of radom sequence (**default:** 0)
/keep_tmp_files	if set, temporary files are not discarded at the end of the run
lmax=, nlmax=	maximum multipole simulation (**default:** 2*$N_{\rm side}$)
nside=, nsmax=	Healpix resolution parameter $N_{\rm side}$
plmfile=	FITS file containing precomputed Spherical Harmonics (deprecated) (**default:** no file)
simul_type=	1) Temperature only 2) Temperature + polarisation 3) Temperature + 1st derivatives 4) Temperature + 1st & 2nd derivatives 5) T+P + 1st derivatives 6) T+P + 1st & 2nd derivates (**default:** 2: T+P)
/silent	if set, works silently
tmpdir=	directory in which are written temporary files (**default:** IDL_TMPDIR (see IDL documentation))
windowfile=	FITS file containing pixel window (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing
winfiledir=	directory where the pixel windows are to be found (**default:** determined automatically by back-end routine). Do not set this keyword unless you really know what you are doing

DESCRIPTION

isynfast is an interface to F90 'synfast' F90 facility. It requires some disk space on which to write the parameter file and the other temporary files. Most data can be provided/generated as an external FITS file, or as a memory array.

RELATED ROUTINES

This section lists the routines related to **isynfast**.

idl	version 6.4 or more is necessary to run isynfast.
synfast	F90 facility called by isynfast.
ialteralm	IDL Interface to F90 alteralm
ianafast	IDL Interface to F90 anafast and C++ anafast_cxx
iprocess_mask	IDL Interface to F90 process_mask
ismoothing	IDL Interface to F90 smoothing

EXAMPLE:

```
isynfast, '$HEALPIX/test/cl.fits', map, fwhm=30, nside=256, /silent
mollview, map, 1, title='I'
mollview, map, 2, title='Q'
```

will synthetize and plot I and Q maps consistent with WMAP-1yr best fit power spectrum and observed with a circular gaussian 30 arcmin beam.

lm2index

Location in HEALPix directory tree: src/idl/misc/lm2index.pro

This IDL routine provides a means to convert the $a_{\ell m}$ degree and order (ℓ, m) into the index $i = \ell^2 + \ell + m + 1$ (in order to be fed to alm2fits routine for instance)

FORMAT

IDL> LM2INDEX, l, m, index

QUALIFIERS

l	Long array containing on INPUT the order ℓ.
m	Long array containing on INPUT the degree m.
index	Long array containing on OUTPUT the index $i = \ell^2 + \ell + m + 1$.

DESCRIPTION

lm2index converts (ℓ, m) into $i = \ell^2 + \ell + m + 1$. Note that by definition $0 \leq |m| \leq \ell$ (the routine does not check for this).

RELATED ROUTINES

This section lists the routines related to **lm2index**.

idl	version 6.4 or more is necessary to run lm2index.
fits2alm	reads a FITS file containing $a_{\ell m}$ values.
alm2fits	writes $a_{\ell m}$ values into a FITS file.
index2lm	routine complementary to lm2index: converts $i = \ell^2 + \ell + m + 1$ into (ℓ, m).

EXAMPLE:

```
lm2index, l, m, index
```

will return in `index` the value $\ell^2 + \ell + m + 1$

median_filter

Location in HEALPix directory tree: src/idl/toolkit/median_filter.pro

This IDL facility allows the median filtering of a Healpix map.

FORMAT

IDL> MEDIAN_FILTER (InputMap, Radius, MedianMap[,ORDERING=, /RING, /NESTED, /FILL_HOLES, /DEGREES, /ARCMIN])

QUALIFIERS

InputMap	(IN) either an IDL array containing a full sky Healpix map to filter ('online' usage), or the name of an external FITS file containing a full sky or cut sky map
Radius	(IN) radius of the disk on which the median is computed. It is in Radians, unless `/DEGREES` or `/ARCMIN` are set
MedianMap	(OUT) either an IDL variable containing on output the filtered map, or the name of an external FITS file to contain the map. Should be of same type of `InputMap`. Flagged pixels (ie, having the value `!healpix.bad_value`) are left unchanged, unless `/FILL_HOLES` is set.

KEYWORDS

/ARCMIN	If set, `Radius` is in arcmin rather than radians
/DEGREES	If set, `Radius` is in degrees rather than radians
/FILL_HOLES	If set, flagged pixels are replaced with the median of the valid pixels found within a distance `Radius`. If there are any.
/NESTED	Same as ORDERING='NESTED'
ORDERING=	Healpix map ordering, should be either 'RING' or 'NESTED'. Only applies to 'online' usage.

/RING Same as ORDERING='RING'

DESCRIPTION

median_filter allows the median filtering of a Healpix map. Each pixel of the output map is the median value of the input map pixels found within a disc of given radius centered on that pixel. Flagged pixels can be either left unchanged or 'filled in' with that same scheme.
If the map is polarized, each of the three Stokes components is filtered separately.
The input and output can either be arrays or FITS files, but they to be both arrays or both FITS files.

RELATED ROUTINES

This section lists the routines related to **median_filter** .

idl version 6.4 or more is necessary to run median_filter

EXAMPLE:

```
median_filter ('map.fits', 10., /arcmin, 'med.fits')
```

Writes in 'med.fits' the median filtered map of 'map.fits' using a disc radius of 10 arcmin

EXAMPLE:

```
map = randomn(seed, nside2npix(256))
median_filter (map, 0.5, /deg, med)
```

Returns in `med` the median filtered map of `map` using a disc radius of 0.5 degrees

mollcursor

Location in HEALPix directory tree: **src/idl/visu/mollcursor.pro**

This IDL facility provides a point-and-click interface for finding the astronomical location, value and pixel index of the pixels nearest to the pointed position on a Mollweide projection of a **HEALPix** map.

FORMAT

IDL> MOLLCURSOR, [cursor_type=, file_out=]

QUALIFIERS

cursor_type= cursor type to be used
(**default:** 34)

file_out= file containing on output the list of point selected with the cursor.
If set to 1, the file will take its default name: 'cursor_catalog.txt'.
If set to a non-empty character string, the file name will be that string

DESCRIPTION

mollcursor should be run immediately following mollview. It gives the longitude, latitude, map value and pixel number corresponding to the cursor position in the window containing the map generated by mollview. Mouse buttons are used to select the function :

left button = display the information relative to the current cursor position,

middle button = print out this information in the IDL command window

right button = quit mollcursor

Note on Mac OS X, X11 and IDL cursor: depending on the Mac OS X version[a] and most importantly on the X Window System being used,[b] the IDL function `cursor`, and therefore **HEALPix** mollcursor, gnomcursor, ... will not work properly under X11. To solve this problem, type the relevant line below at your X11 prompt and restart X11.
If you are using Apple's X11, type under Tiger (10.4):

```
defaults write com.apple.x11 wm_click_through -bool true
```

or, under Leopard (10.5), Snow Leopard (10.6), Lion (10.7):

```
defaults write org.x.x11 wm_click_through -bool true
```

If you are using Xquartz (for eg, Montain Lion (10.8), Mavericks (10.9), Yosemite (10.10), El Capitan (10.11), Sierra (10.12) or High Sierra (10.13)):

```
defaults write org.macosforge.xquartz.X11 wm_click_through
-bool true
```

and if you are using MacPort's X11 (package xorg-server):

```
defaults write org.macports.X11 wm_click_through -bool true
```

(see http://www.idlcoyote.com/misc_tips/maccursor.html and the section Mac OS X, X11 and IDL cursor in "**HEALPix** Installation Documentation").
And finally, mollcursor obviously requires the '3 button mouse' to be enabled, which can be done in the X11 Preferences menu, or if Xquartz is used (see `man Xquartz`) via:

```
defaults write org.macosforge.xquartz.X11 enable_fake_buttons
-bool true
```

[a] the command `sw_vers -productVersion` can be used to know the Mac OS X version being used

[b] the command `ls -lrt $HOME/Library/Preferences/*[xX]11*plist` can be used to determine the X implementation and its configuration file

RELATED ROUTINES

This section lists the routines related to **mollcursor**.

idl	version 6.4 or more is necessary to run mollcursor
ghostview	ghostview or a similar facility is required to view the Postscript image generated by mollcursor.
xv	xv or a similar facility is required to view the GIF/PNG image generated by mollcursor (a browser can also be used).
synfast	This **HEALPix** facility will generate the FITS format sky map to be input to mollcursor.
cartview	IDL facility to generate a Cartesian projection of a **HEALPix** map.
cartcursor	interactive cursor to be used with cartview
gnomview	IDL facility to generate a gnomonic projection of a **HEALPix** map.
gnomcursor	interactive cursor to be used with gnomview
mollview	IDL facility to generate a Mollweide projection of a **HEALPix** map.
mollcursor	interactive cursor to be used with mollview
orthview	IDL facility to generate an orthographic projection of a **HEALPix** map.
orthcursor	interactive cursor to be used with orthview

EXAMPLE:

```
mollcursor
```

After mollview reads in a map and generates its mollweide projection, mollcursor is run to know the position and flux of bright synchrotron sources, for example.

mollview

Location in HEALPix directory tree: src/idl/visu/mollview.pro

This IDL facility provides a means to visualise a full sky Mollweide projection of **HEALPix** and COBE Quad-Cube maps in an IDL environment. It also offers the possibility to generate GIF, JPEG, PDF, PNG and Postscript color-coded images of the projected map. The projected (but not color-coded) data can also be output in FITS files and IDL arrays.

FORMAT

IDL> MOLLVIEW, File [, Select] [, ASINH=, BAD_COLOR=, BG_COLOR=, CHARSIZE=, CHARTHICK=, COLT=, COORD=, /CROP, CUSTOMIZE=, DEFAULT_SETTINGS=, EXECUTE=, FACTOR=, FG_COLOR=, FITS=, /FLIP, GAL_CUT=, GIF=, GLSIZE=, GRATICULE=, /HALF_SKY, HBOUND=, /HELP, /HIST_EQUAL, HXSIZE=, IGLSIZE=, IGRATICULE=, JPEG=, LATEX=, /LOG, MAP_OUT=, MAX=, MIN=, /NESTED, /NO_DIPOLE, /NO_MONOPOLE, /NOBAR, /NOLABELS, /NOPOSITION, OFFSET=, OUTLINE=, PDF=, PFONTS=, PNG=, POLARIZATION=, /PREVIEW, PS=, PXSIZE=, PYSIZE=, RESO_ARCMIN=, RETAIN=, ROT=, /SAVE, /SHADED, /SILENT, SILHOUETTE=, STAGGER=, SUBTITLE=, TITLEPLOT=, TRANSPARENT=, TRUECOLORS=, UNITS=, WINDOW=, XPOS=, YPOS=]

Several visualization routines have a similar interface. Their **qualifiers** and **keywords** are all listed here, and the routines to which they apply are coded in the 'routine' column as: A: azeqview, C: cartview, G: gnomview, M: mollview, O: orthview and all: all of them

Qualifiers should appear in the order indicated. They can take a range of values, and some of them are optional.
Keywords are optional, and can appear in any order. They take the form `keyword=value` and can be abbreviated to a non ambiguous form (ie, `factor=10.0` can be replaced by `fac = 10.0`). They generally can take a range of values, but some of them (noted as `/keyword` below) are boolean switches: they are either present (or set to 1) or absent (or set to 0).

QUALIFIERS

name	routines	description
File	all	Required name of a (possibly gzip compressed) FITS file containing the **HEALPix** map in an extension or in the image field, *or* name of an *online* variable (either array or structure) containing the (RING or NESTED ordered) **HEALPix** map (See note below); if Save is set : name of an IDL saveset file containing the **HEALPix** map stored under the variable `data` (**default:** none) Note on online data: in order to preserve the integrity of the input data, the content of the array or structure `File` is replicated before being possibly altered by the map making process. Therefore plotting online data will require more memory than reading the data from disc directly, and is not recommended to visualize data sets of size comparable to that of the computer memory. Note on high resolution cut sky data: cut sky data (in which less than 50% of the sky is observed), can be processed with a minimal memory foot-print, by not allocating fake full map. In the current release, two restrictions apply: the input data set must be read from a FITS file in 'cut4' format, and the `POLARIZATION` IDL keyword (described below) must be 0 (default value). See Example #4 on page 121. see also: `TrueColors`.
Select	all	Optional column of the BIN FITS table to be plotted, can be either – a name : value given in TTYPEi of the FITS file NOT case sensitive and can be truncated, (only letters, digits and underscore are valid) – an integer : number i of the column containing the data, starting with 1 (also valid if `File` is an online array) (**default:** 1 for full sky maps, 'SIGNAL' column for FITS files containing cut sky maps) (see the Examples below)

KEYWORDS

name	routines	description
ASINH=	all	if set, the color table is altered to emulate an non-linear mapping of the input data enhancing the low contrast regions. If `asinh=1` the mapping is $y = \sinh^{-1}(x)$, such that $y \approx x$ when $x \ll 1$ and $y \approx \ln(2x)$ when $x \gg 1$. If `asinh=2` the mapping is $y = \sinh^{-1}(x/2)/\ln(10)$, such that $y \approx 0.21x$ when $x \ll 1$ and $y \approx \log(x)$ when $x \gg 1$. Here x is the input data, optionally altered by `Factor` and `Offset`. This option can *not* be used in conjonction with `/LOG` nor `/HIST_EQUAL`.
BAD_COLOR=	all	color given to missing pixels (having `!healpix.bad_value` ($= -1.6375\,10^{30}$) or `NaN` value on input). The color can be provided as either: – a single integer in [0,255], specifying the index to be used in the color table chosen via COLT (in which the indexes 0, 1 and 2 are reserved for black, white and grey respectively), – a 3 element vector, with each element in [0,255], specifying the amount of RED, GREEN and BLUE – a 7-character string, starting with '#', specifying the color in HTML Hexadecimal fashion (eg, '#ff0000' for red). (**default:** neutral grey (=2, =[175, 175, 175], ='#afafaf')) see also: BG_COLOR, FG_COLOR, TRANSPARENT
BG_COLOR=	all	color given to background pixels (outside the sphere). See BAD_COLOR for expected format. (**default:** white (=1, =[255, 255, 255], ='#ffffff')) see also: FG_COLOR, TRANSPARENT
CHARSIZE=	all	overall multiplicative factor applied to the size of all characters appearing on the plot (**default:** 1.0); see also: CUSTOMIZE
CHARTHICK=	all	character thickness (in TITLEPLOT, SUBTITLE and color bar labeling). Other characters thickness (such as graticule labels), can be controlled with `!P.CHARTHICK`. (**default:** 1)

name	routines	description
COLT=	all	color table index: – Indexes in [0,40] are reserved for standard IDL color tables, while [41,255] are used for user defined color tables read from disc (created and written to disc with `MODIFYCT`), if any. – Indexes 1001 (or `'planck1'`, case insensitive) and 1002 (or `'planck2'`) are reserved for Planck color tables 1 and 2 generated by `planck_colors`. See Example #6 on page 124. – If the index does not match any existing table, or if it is above 255, the current online table (modifiable with `TVLCT`, `XLOADCT`, `XPALETTE`, ... or eg, J. Davenport's `cubehelix.pro` implementation of D. Green 's cubehelix color scheme) is used instead. –If `colt`< 0, the IDL color table ABS(colt) is used, but the scale is reversed (ie a red to blue scale becomes a blue to red scale). Note: -0.1 can be used as negative 0. (**default:** 33 (Blue-Red)) see also: `TrueColors`
COORD=	all	vector with 1 or 2 elements describing the coordinate system of the map; either – 'C' or 'Q' : Celestial2000 = eQuatorial, – 'E' : Ecliptic, – 'G' : Galactic if coord = ['x','y'] the map is rotated from system 'x' to system 'y' if coord = ['y'] the map is rotated to coordinate system 'y' (with the original system assumed to be Galactic unless indicated otherwise in the input file) see also: Rot
/CROP	all	if set, the image produced (in GIF/JPEG/PDF/PNG/PS and on screen) only contains the projected map and no title, color bar, ... see also: Gif, Jpeg, Pdf, Png, Ps

name	routines	description
CUSTOMIZE=	all	User provided structure containing customization parameters of the produced output, whose default values are listed in DEFAULT_SETTINGS. The accepted inputs are `ASPOS.X, ASPOS.Y`: X,Y location of astronomical coordinates label (which can be removed altogether with /NOPOSITION, only applicable to gnomview), `CBAR.DX, CBAR.DY`: length and width of color bar (which can be removed with /NOBAR), the bar is centered, at an automatically determined height `CBAR.SPACES`: 3-element vector listing the strings to be inserted between the map minimum value label, the color bar, the map maximum value, and the map units (read from the FITS file or provided by UNITS) (**default:** 3 single spaces), `CBAR.TY`: vertical offset of the text (min, max and units labels) with respect to the color bar (**default:** 0); **Note:** the character size of the text accompanying the color bar is fully determined by the keyword Charsize, `CBAR.BOX`: thickness of the black box drawn around the color bar (**default:** 0: no box); the final thickness is `2*cbar.box*!p.thick` in PDF and PS, and `cbar.box*!p.thick` otherwise, where `!p.thick` is assumed to have a value of 1.0 unless specified otherwise. `CRING.DX, CRING.XLL, CRING.YLL`: radius and X,Y location of lower left corner of the color disc showing the polarization direction when POLARIZATION=3 `PDF.DEBUG`: if set to 1, and SILENT is not set, then debugging information on the PDF generation will be printed (when applicable), and the intermediate Postscript file will be kept `SUBTITLE.X, SUBTITLE.Y, SUBTITLE.CHARSIZE`: control the X,Y location of the plot subtitle (X=0 is left justified, X=0.5 is centered and X=1 is right justified), and its final character size, which is the product of the number `SUBTITLE.CHARSIZE` with the one provided in the keyword Charsize `TITLE.X, TITLE.Y, TITLE.CHARSIZE`: same as above, applied to the plot title (titleplot), `VSCALE.X, VSCALE.Y`: X,Y location of scale calibrating the polarization rods (whose length and spacing in the main plotting area can be tuned with POLARIZATION=[3, length, spacing]) `VSCALE.TY`: vertical offset of the text next to the calibrating rod. See Example #7 on page 125.

name	**routines**	**description**
DEFAULT-_SETTINGS=	all	Structure containing on output the default values (slightly projection dependent) of the plotting parameters that can be customized with CUSTOMIZE. As shown in Example #7 on page 125, the returned structure can be inspected with the routine `help_st`.
EXECUTE=	all	character string containing IDL command(s) to be executed in the plotting window. See Example #3 on page 122.
FACTOR=	all	scalar multiplicative factor to be applied to the valid data the data plotted is of the form Factor*(data + Offset) This does not affect the flagged pixels Can be used together with ASINH or LOG When used with TRUECOLORS, FACTOR can be a 3-element vector. see also: ASINH, Offset, LOG, Truecolors (**default:** 1.0)
FG_COLOR=	all	color of title and subtile characters, graticule lines and labels, units, outlines ... See BAD_COLOR for expected format. (**default:** black (=0, =[0, 0, 0], ='#000000')) see also: BAD_COLOR, BG_COLOR
FITS=	all	string containing the name of an output FITS file with the projected map in the primary image – if set to 1 : output the plot in plot_*proj*.fits, where *proj* is either *cartesian, gnomic, mollweide*, or *orthographic* depending on the projection in use; – if set to a file name : output the plot in that file. (**default:** 0: no .FITS done) In the case of Orthographic projection, HALF_SKY must be set. Except for the color mapping, all the keywords and options apply to the projected map, ie: its size is determined by PXSIZE (and PYSIZE when applicable), its angular resolution by RESO_ARCMIN when applicable, its orientation and coordinates by ROT and COORD respectively, ... For compatibility with standard FITS viewers (including STIFF), unobserved pixels, and pixels outside the sphere, take the value `NaN` (ie `!values.f_nan` in IDL). The resulting FITS file can be read in IDL with eg. map=`readfits`(*filename*). see also: Map_out

name	routines	description
/FLIP	all	if set the longitude increases to the right, whereas by default (astronomical convention) it increases towards the left
GAL_CUT=	—MO	(positive float) specifies the symmetric galactic cut in degrees outside of which the monopole and/or dipole fitting is done (**default:** 0: monopole and dipole fit done on the whole sky) (see also: No_dipole, No_monopole)
GIF=	all	string containing the name of a .GIF output if set to 1 : outputs the plot in `plot_`*projection*`.gif`, where *projection* is either `azimequid`, `cartesian`, `gnomic`, `mollweide` or `orthographic`, if set to a file name : outputs the plot in that file Please note that the resulting GIF image might not always look as expected. The reason for this is a problem with 'backing store' in the IDL-routine TVRD. Please read the IDL documentation for more information. (**default:** no .GIF done) see also: Crop, Jpeg, Pdf, Png, Preview, Ps and Retain
GLSIZE=	CGMO	character size of the graticule labels in units of `Charsize`. Can be a scalar (which applies to both parallel and meridian labels), or a 2 element vector (interpreted as [meridian_label_size, parallel_label_size]) (**default:** 0: no labeling of graticules). see also: Charsize, Graticule, Iglsize, Igraticule
GRATICULE=	CGMO	if set, puts a graticule (ie, longitude and latitude grid) in the *output* astrophysical coordinates with delta_long = delta_lat = gdef degrees if set to a scalar $x >$ gmin then delta_long = delta_lat = x if set to [x,y] with $x, y >$ gmin then delta_long = x and delta_lat = y cartview : gdef = 45, gmin = 0 gnomview : gdef = 5, gmin = 0 mollview : gdef = 45, gmin = 10 orthview : gdef = 45, gmin = 10 Note that the graticule will rotate with the sphere if Rot is set. To outline only the equator set graticule=[360,90]. The automatic labeling of the graticule is controlled by `Glsize` The graticule line thickness is controlled via !P.THICK. (**default:** 0 [no graticule]) see also: Igraticule, Rot, Coord, Glsize

name	**routines**	**description**
/HALF_SKY	—O	if set, only shows only one half of the sky (centered on (0,0) or on the location parametrized by Rot) instead of the full sky
HBOUND=	all	scalar or vector of up to 3 elements. If Hbound[i] is set to a valid $N_{\rm side}$, the routine will overplot the **HEALPix** pixel boundaries corresponding to that $N_{\rm side}$ on top of the map. The first $N_{\rm side}$ will be plotted with solid lines, the second one (if any) with dashes and the third one (if any) with dots. Obviously, better results are obtained for Hbounds elements in growing order. Since 0-valued boundaries are not plotted, but used for linestyle assignment, providing Hbound=[0,4] (or [0,0,4]) will plot $N_{\rm side} = 4$ boundaries with dashes (resp. dots), while Hbound=4 would plot the same boundaries with solid lines.
/HELP	all	if set, the routine header is printed (by doc_library) and nothing else is done
/HIST_EQUAL	all	if set, uses a histogram equalized color mapping (useful for non gaussian data field) (**default:** uses linear color mapping and puts the level 0 in the middle of the color scale (ie, green for Blue-Red) unless Min and Max are not symmetric) see also: Asinh, Log
HXSIZE=	all	horizontal dimension (in cm) of the Postscript printout (**default:** 26 cm $\simeq$ 10 in) see also: Pxsize
IGLSIZE=	CGMO	character size of the input coordinates graticule labels in units of `Charsize`. Either scalar or 2-element vector (see Glsize). (**default:** 0: no labeling of graticules). see also: Charsize, Igraticule
IGRATICULE=	CGMO	if set, puts a graticule (ie, longitude and latitude grid) in the *input* astrophysical coordinates. See Graticule for conventions and details. If both Graticule and Igraticule are set, the latter will be represented with dashes. The automatic labeling of the graticule is controlled by `Iglsize` (**default:** 0 [no graticule]) see also: Graticule, Rot, Coord, Iglsize

name	routines	description
JPEG=	all	string containing the name of a *lossless* .JPEG output file if set to 1 : outputs the plot in `plot_`*projection*`.jpeg`, where *projection* is either `azimequid`, `cartesian`, `gnomic`, `mollweide` or `orthographic`, if set to a file name : output the plot in that file (**default:** no .JPEG done) see also: Crop, Fits, Gif, Map_out, Png, Preview, Pdf, Ps, and Retain
LATEX=	all	if set to 1 or 2, enables LaTeX handling of character strings such as Titleplot, Subtitle and Units – if set to 2 *with* PS or PDF outputs, those strings (and the graticule labels) will be processed by genuine LaTeX and inserted in the final PS or PDF file using *psfrag* package (requires the ubiquitous `latex` and its *color*, *geometry*, *graphicx* and *psfrag* packages as well as `dvips`). In this case, the Pfonts settings will be ignored. Note that `cgPStoRASTER`, ImageMagick `convert` and/or GraphicsMagick `gm convert` can be used to turn a PS or PDF file into high resolution GIF, JPEG or PNG file. Beware that the option `latex=2` may not work properly under versions 0.9.5 and older of `gdl`. – if set to 1, with whatever output (GIF, JPEG, PDF, PNG, PS, or X) LaTeX is partially emulated with `TeXtoIDL` routines, which are now shipped with **HEALPix** (no extra requirements). In this case, Pfonts settings can be used. (**default:** 0, no LaTeX handling)
/LOG	all	display the log of map. This is intended for application to positive definite maps only, eg. Galactic foreground emission templates; for arbitrary maps, use /ASINH instead. see also: Asinh, Factor, Hist_Equal, Offset
MAP_OUT=	all	variable that will contain the projected map on output. Except for the color mapping, all the keywords and options apply to the projected map, ie: its size is determined by PXSIZE (and PYSIZE when applicable), its angular resolution by RESO_ARCMIN when applicable, its orientation and coordinates by ROT and COORD respectively, ... Unobserved pixels, and pixels outside the sphere, take value `!healpix.bad_value` ($= -1.6375\,10^{30}$). see also: Fits

name	**routines**	**description**
MAX=	all	Set the maximum value for the plotted signal (**default:** is to use the actual signal maximum).
MIN=	all	Set the minimum value for the plotted signal (**default:** is to use the actual signal minimum).
/NESTED	all	specify that the online data is ordered in the nested scheme
/NO_DIPOLE	—MO	if set (and Gal_cut is not set) the best fit monopole *and* dipole over all valid pixels are removed; if Gal_cut is set to $b > 0$, the best monopole and dipole fit is performed on all valid pixels with |galactic latitude| $> b$ (in deg) and is removed from all valid pixels (**default:** 0 (no monopole or dipole removal)) can NOT be used together with No_monopole see also: Gal_cut, No_monopole
/NO_MONOPOLE	–MO	if set (and Gal_cut is not set) the best fit monopole over all valid pixels is removed; if Gal_cut is set to $b > 0$, the best monopole fit is performed on all valid pixels with |galactic latitude| $> b$ (in deg) and is removed from all valid pixels (**default:** 0 (no monopole removal)) can NOT be used together with No_dipole see also: Gal_cut, No_dipole
/NOBAR	all	if set, the color bar (or the color wheel used when Polarization=2) is hidden; see also: CUSTOMIZE
/NOLABELS	all	if set, color bar labels (min and max) are not present, (**default:** labels are present); see also: CUSTOMIZE
/NOPOSITION	–G–	if set, the astronomical location of the map central point is not indicated; see also: CUSTOMIZE
OFFSET=	all	scalar additive factor to be applied to the valid data the data plotted is of the form Factor*(data + Offset) This does not affect the flagged pixels can be used together with ASINH or LOG When used with TRUECOLORS, OFFSET can be a 3-element vector. see also: ASINH, Factor, LOG, TRUECOLORS (**default:** 0.0)

name	routines	description
OUTLINE=	CGMO	IDL structure, array of (same size) structures, or structure of (mixed size) structures (see Note below), containing the description of one (or several) outline(s) to be overplotted on the final map. For each contour or point list, the corresponding (sub)structure should contain the following fields: – 'COORD': coordinate system (either 'C'/'Q', 'G' or 'E') of the contour (same meaning as in Coord) – 'RA': RA/longitude coordinates of the contour vertices (array or scalar) – 'DEC': Dec/latitude coordinates of the contour vertices (array or scalar) and can optionally contain the fields: – 'LINE[STYLE]': (optional, scalar) **+2**: black dashes, **+1**: black dots, **0**: black solid (default), **-1**: black dots on white background, **-2**: black dashes on white background – 'PSY[M]': (optional, scalar) symbol used to represent vertices (same meaning as standard PSYM in IDL. If $9 \leq \|\text{psym}\| \leq 46$, D. Fanning's `cgSYMCAT.PRO` symbols definition will be used; for example, psym=9 is an open circle). If ≤ 0, the vertices are represented with the chosen symbols, and connected by arcs of geodesics; if > 0, only the vertices are shown (**default:** 0) – 'SYM[SIZE]': (optional, scalar) vertice symbol size (same meaning as SYMSIZE in IDL), (**default:** 1) The line and symbol thickness can be controlled (indirectly) via !P.THICK. Notes: when applicable, the vertices are connected by segments of geodesics. To obtain a better looking outline, increase the number of vertices provided. The outline does not have to be closed. The procedure will NOT attempt to close the outline. See Example #2 below. **Note:** several outlines (let's say `circle` and `triangle`) can be overplotted at once by gathering the respective structures into an array (`outline=[circle,triangle]`) if they have the same features and in particular the same number of vertices, or in one meta-structure (`outline={s1:circle,s2:triangle}`) in all cases. see also: Coord, Graticule

name	**routines**	**description**
PDF=	all	string containing the name of a .PDF output if set to 0 : no PDF output if set to 1 : outputs the plot in `plot_`*projection*`.pdf`, where *projection* is either `azimequid`, `cartesian`, `gnomic`, `mollweide` or `orthographic`, if set to a file name : outputs the plot in that file (**default:** 0) The PDF file is produced from a PostScript file using the script `epstopdf` now shipped with **HEALPix**. Note that `epstopdf` usually requires a fully functional implementation of the fairly widespread `gs`, aka `Ghostscript`, which may however not be available on the computation dedicated nodes of some computer clusters. If the resulting PDF file is not properly rotated (ie landscape orientation instead of portrait), and/or has excessive white margins, the scripts `pdf90`, part of the package `pdfjam`, and/or `pdfcrop`, often included in PDFTeX installations, can respectively prove very useful. see also: Preview, Gif, Jpeg, Png, Ps

name	routines	description
PFONTS=	all	2-element vector of integers [p_0, p_1] selecting the default IDL font of character strings such as the Subtitle, Titleplot and Units. p_0 must be in $\{-1, 0, 1\}$ and selects the origin of the fonts among -1: Hershey Vector, 0: Device Specific and 1: True Type Fonts. p_1 must be in $\{2, \ldots, 20\}$ and selects the starting font of the character strings as described here. The font can be changed within each string with embedded formatting commands, as discussed on `http://www.exelisvis.com/docs/Fonts_and_Colors.html`. (**default:** [-1,6], corresponding to the Hershey vector font of type 'Complex Roman', and is equivalent to typing `!p.font=-1` and prepending the Subtitle, Titleplot and Units strings with `'!6'`). Note that PFONTS will be ignored if Latex=2 *and* PDF or PS are set.
PNG=	all	string containing the name of a .PNG output if set to 1 : outputs the plot in `plot_`*projection*`.png`, where *projection* is either `azimequid`, `cartesian`, `gnomic`, `mollweide` or `orthographic`, if set to a file name : outputs the plot in that file Please note that the resulting PNG image might not always look as expected. The reason for this is problems with 'backing store' in the IDL-routine TVRD. Please read the IDL documentation for more information. (**default:** no .PNG done) see also: Crop, Fits, Gif, Jpeg, Map_out, Preview, Pdf, Ps, and Retain

name	routines	description
POLARIZATION=	all	if set to 0: no polarization information is plotted; 1: the AMPLITUDE $P = \sqrt{U^2 + Q^2}$ of the polarization is plotted (as long as the input data contains polarization information (ie, Stokes parameter Q and U for each pixel)); 2: the ANGLE $\phi = \tan^{-1}(U/Q)/2$ of the polarization is plotted Note: the angles are color coded with a fixed color table (independent of Colt); 3: –the temperature is color coded (with a color table defined by Colt), –and the polarization is overplotted as small RODS (or headless VECTORS). `Polarization` can then be a 4-element vector (the first element being 3). The second element controls the average length of the rods (**default:** 1), the third one controls their spacing (**default:** 1), while the fourth one controls their thickness (which also depends in a device dependent manner on `!P.THICK`) (**default:** 1). Non-positive values are replaced by 1. see also: Customize (**default:** 0) **Note 1:** The representation of the polarization direction (options 2 and 3 above), include the effects of the rotations and/or changes or astronomical coordinates (controlled by ROT and COORD respectively) but do not include the effects of the distortions induced by the projection from the sphere to the plan. Because the polarization usually has more power at small scales, it must generally be represented on maps of small patches of the sky to remain legible, in which case the projection-induced distortions are small. **Note 2:** when `polarization=2` or `polarization=3`, the visualisation routines behavior will depend on the value of the `POLCCONV` FITS keyword (see note on POLCCONV in The **HEALPix** Primer)

name	routines	description
/PREVIEW	all	if set, the external file generated with Gif, Jpeg, Pdf, Png, or Ps will be previewed with the visualisation applications (eg, `gv`, `display` or `open`) chosen during the **HEALPix** IDL/GDL configuration step
PS=	all	if set to 0 : no PostScript output if set to 1 : outputs the plot `plot_`*projection*`.ps`, where *projection* is either `azimequid`, `cartesian`, `gnomic`, `mollweide` or `orthographic`, if set to a file name : outputs the plot in that file (**default:** 0) see also: Preview, Gif, Jpeg, Pdf, Png
PXSIZE=	all	set the number of horizontal screen_pixels or postscript_color_dots of the plot (useful for high definition color printer) or elements of the output map (**default:** 800 (Mollview and full sky Orthview), 600 (half sky Orthview), 500 (Cartview and Gnomonic)) see also: FITS, GIF, JPEG, MAP_OUT, PDF, PNG, PS.
PYSIZE=	ACG–	set the number of vertical screen_pixels or postscript_color_dots of the plot (**default:** Pxsize).
RESO_ARCMIN=	ACG–	size of screen_pixels or postscript_color_dots in arcmin (**default:** 1.5) see also: FITS, GIF, JPEG, MAP_OUT, PDF, PNG, PS.
RETAIN=	all	specifies the type of backing store to use for direct graphics windows in {0,1,2}. (**default:** 2). See IDL documentation for details.
ROT=	all	vector with 1, 2 or 3 elements specifing the rotation angles in DEGREES to apply to the map in the 'output' coordinate system (see Coord) = (lon0, [lat0, rat0]) lon0 : longitude of the point to be put at the center of the plot the longitude increases Eastward, ie to the left of the plot (**default:** 0) lat0 : latitude of the point to be put at the center of the plot (**default:** 0) rot0 : anti clockwise rotation to apply to the sky around the center (lon0, lat0) before projecting (**default:** 0)

name	routines	description
/SAVE	all	if set, assumes that File is in IDL saveset format, the variable saved should be DATA
/SHADED	—O	if set, the orthographic sphere is shaded, using a Phong model, to emulate 3D viewing. The sphere is illuminated by isotropic ambiant light plus a single light source. Can NOT be used with GIF.
/SILENT	all	if set, the program runs silently, and extra debugging switches such as customize={pdf:{debug:1}} will be ignored.
SILHOUETTE=	—MO	if set to a scalar or 2-element vector with silhouette[0] $\neq 0$, a silhouette is drawn around the map. Its thickness is proportional to abs(silhouette[0]) (and also depends in a device dependent manner on `!P.THICK`) Its color is determined by abs(silhouette[1]) in [0,255] (**default:** 0:FG_COLOR). See Example #7 on page 125.
STAGGER=	—O	Scalar or 2 element vector: – if `stagger[0]` is in $]0, 2]$, three copies of the same sphere centered respectively at `[-stagger[0], 0, stagger[0]]` (expressed in radius units) along the plot horizontal axis are shown in ORTHOGRAPHIC projection – if set, `stagger[1]` defines the angle of rotation (in degrees) applied to the left and right partial spheres: the *lhs* sphere is rotated downward by the angle provided, while the *rhs* one is rotated upward. Rotations are swapped if FLIP is set. Currently **can not** be used with Graticule nor igraticule
SUBTITLE=	all	String containing the subtitle to the plot see also: Titleplot, Latex, Customize
TITLEPLOT=	all	String containing the title of the plot, if not set the title will be File see also: Subtitle, Latex, Customize
TRANSPARENT=	all	If set to 1, the input data pixels with value `!healpix.bad_value` ($= -1.6375\,10^{30}$) will appear totally transparent on the output PNG file (instead of the usual grey or BAD_COLOR). If set to 2, the background pixels will be transparent (instead of the usual white or BG_COLOR) If set to 3, both the grey and white pixels will look transparent. Active only in conjunction with PNG

name	routines	description
TRUECOLORS=	all	if the input data is of the form [Npix,3], then the 3 fields are respectively understood as Red, Green, Blue True-Color channels, and the color table is ignored. – If set to 1, the mapping field-intensity to color is done for the 3 channels at once. (see also: Factor, Offset) – If set to 2, that mapping is done for each channel separately (in that case, MIN and MAX keywords are ignored).
UNITS=	all	String containing the units, to be put on the right hand side of the color bar, overrides the value read from the input file, if any see also: Nobar, Nolabels, Latex
WINDOW=	all	IDL window index (integer) – if WINDOW < 0: virtual window: no visible window opened. Can be used with PNG, JPEG, or GIF, in particular if those files are larger than the screen. **Note:** The Z buffer will be used instead of the X server, allowing much faster production of the image over a slow network – if WINDOW in $[0, 31]$: the specified IDL window with index WINDOW is used (or reused). Can be used to have a sequence of images appear in the same window – if WINDOW > 31: a free (=unused) window with a random index > 31 will be created and used. (**default:** 32, if X server properly set; -1, otherwise)
XPOS=	all	The X position on the screen of the lower left corner of the window, in device coordinate
YPOS=	all	The Y position on the screen of the lower left corner of the window, in device coordinate

DESCRIPTION

mollview reads in a **HEALPix** sky map in FITS format and generates a Mollweide projection of it, that can be visualized on the screen or exported in a GIF, JPEG, PNG, PDF or Postscript file. mollview allows the selection of the coordinate system, map size, color table, color bar inclusion, linear, log, hybrid or histogram equalised color scaling, maximum and minimum range for the plot, plot-title *etc.* It also allows the representation of the polarization field.

RELATED ROUTINES

This section lists the routines related to **mollview**.

idl	version 6.4 or more is necessary to run mollview
gv, ghostview	gv, ghostview or a similar facility is required to view the Postscript or PDF images generated by mollview.
display, xv	display, xv or a similar facility is required to view the GIF/JPEG/PNG image generated by mollview (a browser can also be used).
synfast, smoothing	These F90 **HEALPix** facilities will generate the FITS format sky maps to be input to mollview.
isynfast, ismoothing	These IDL routines will generate the FITS format sky maps to be input to mollview.
cartview	IDL facility to generate a Cartesian projection of a **HEALPix** map.
cartcursor	interactive cursor to be used with cartview
gnomview	IDL facility to generate a gnomonic projection of a **HEALPix** map.
gnomcursor	interactive cursor to be used with gnomview
mollview	IDL facility to generate a Mollweide projection of a **HEALPix** map.
mollcursor	interactive cursor to be used with mollview
orthview	IDL facility to generate an orthographic projection of a **HEALPix** map.
orthcursor	interactive cursor to be used with orthview
planck_colors	creates color tables used in Planck 2013 publications

EXAMPLES: #1

```
mollview, 'planck100GHZ-LFI.fits', min=-100, max=100, /graticule, $
   title='Simulated Planck LFI Sky Map at 100GHz'
```

mollview reads in the map 'planck100GHZ-LFI.fits' and generates an output image in which the temperature scale has been set to lie between ± 100 (μK), a graticule with a 45 degree step in longitude and latitude is drawn, and the title 'Simulated Planck LFI Sky Map at 100GHz' appended to the image.

EXAMPLES: #2

```
map = findgen(48)
triangle= create_struct('coord','G','ra',[0,80,0],'dec',[40,45,65])
mollview,map, graticule=[45,30],rot=[10,20,30],$
     title='Mollweide projection',subtitle='mollview', $
     outline=triangle
```

makes a Mollweide projection of a pixel index map (see Figure 1c on page 122) after an arbitrary rotation, with a graticule grid (with a 45^o step in longitude and 30^o in latitude) and an arbitrary (triangular) outline

EXAMPLES: #3

```
map = findgen(48)
mycommand = 'x=findgen(64)/10.  & ' + $
     'plot,x,sin(x),pos=[0.8,0.8,0.99,0.99],/noerase &' +$
     'xyouts,0.5,0.5,"Hello World !",/normal,charsize=2,align=0.5'
mollview,map, execute=mycommand, png='plot_example_execute.png',$
     /preview,/graticule,/glsize
```

produces a PNG file containing a Mollweide projection of a pixel index map with labeled graticules, a simple sine wave in the upper right corner, and some greetings, as shown on Figure 2 on page 122

EXAMPLES: #4

```
pixel = l64indgen(400000)
signal = pixel * 10.0
file = 'cutsky.fits'
write_fits_cut4, file, pixel+100000, signal, nside=32768, /ring
gnomview, file, rot=[0,90], grat=30, title='high res.  cut-sky map'
```

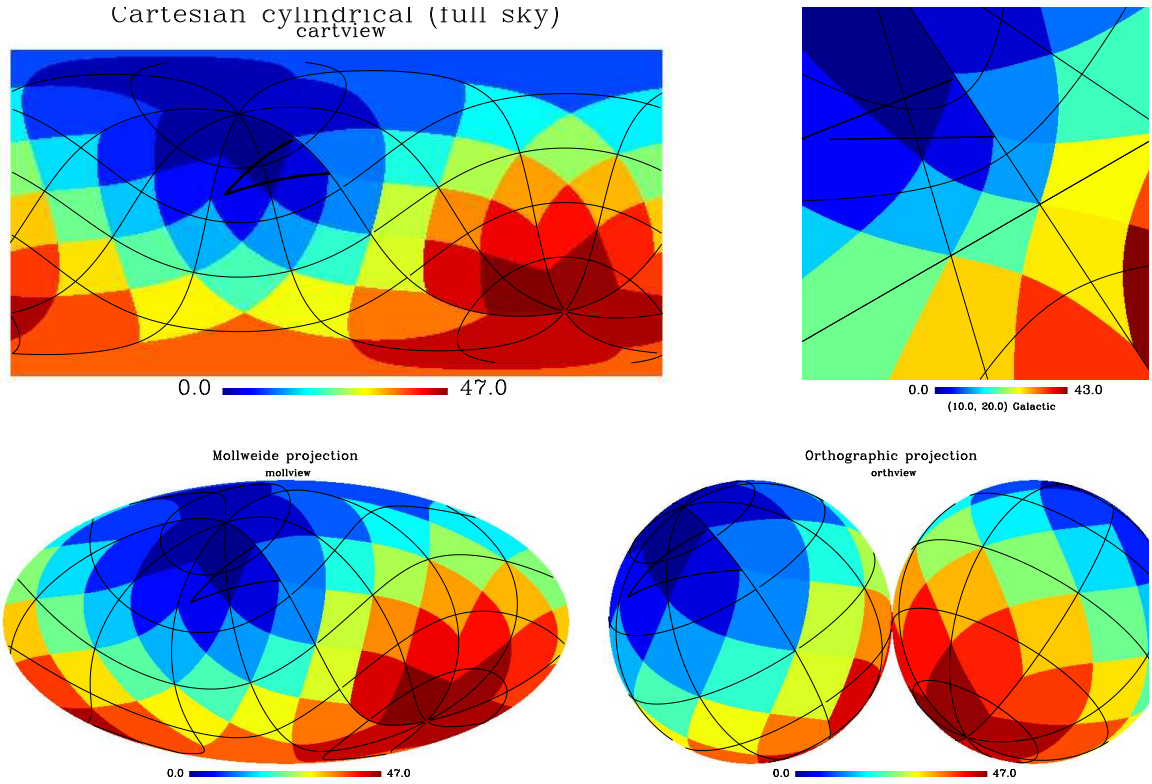

Figure 1: Figures produced by cartview, gnomview, mollview and orthview, see respective routine documentation for details.

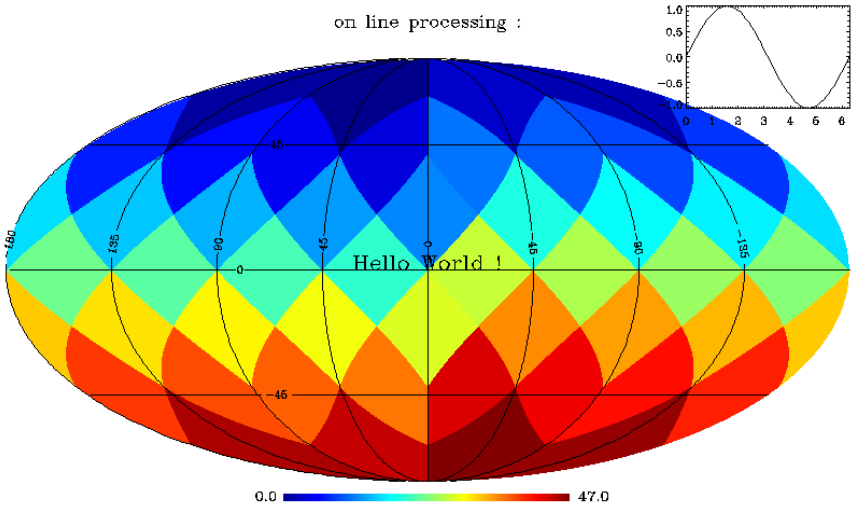

Figure 2: Figure produced by Example #3 .

produces and plots a high resolution map (6.4 arcsec/pixel), in which only a very small subset of pixels is observed

EXAMPLES: #5

```
file = 'wmap_band_iqumap_r9_5yr_K_v3.fits'
mollview, file, title='Linear Color Scale', /silent
mollview, file,/asinh,title='Sinh!u-1!n Color Scale' , /silent
mollview, file,/hist, title='Histogram Equalized Color Scale', /silent
mollview, file,/log, title='Log Scale', /silent
```

produces Mollweide projections of the same map (here the WMAP-5yr K band) with various color scales: linear, Inverse Hyperbolic Sine, Histogram Equalized, and Log. See Figure 3 on page 123

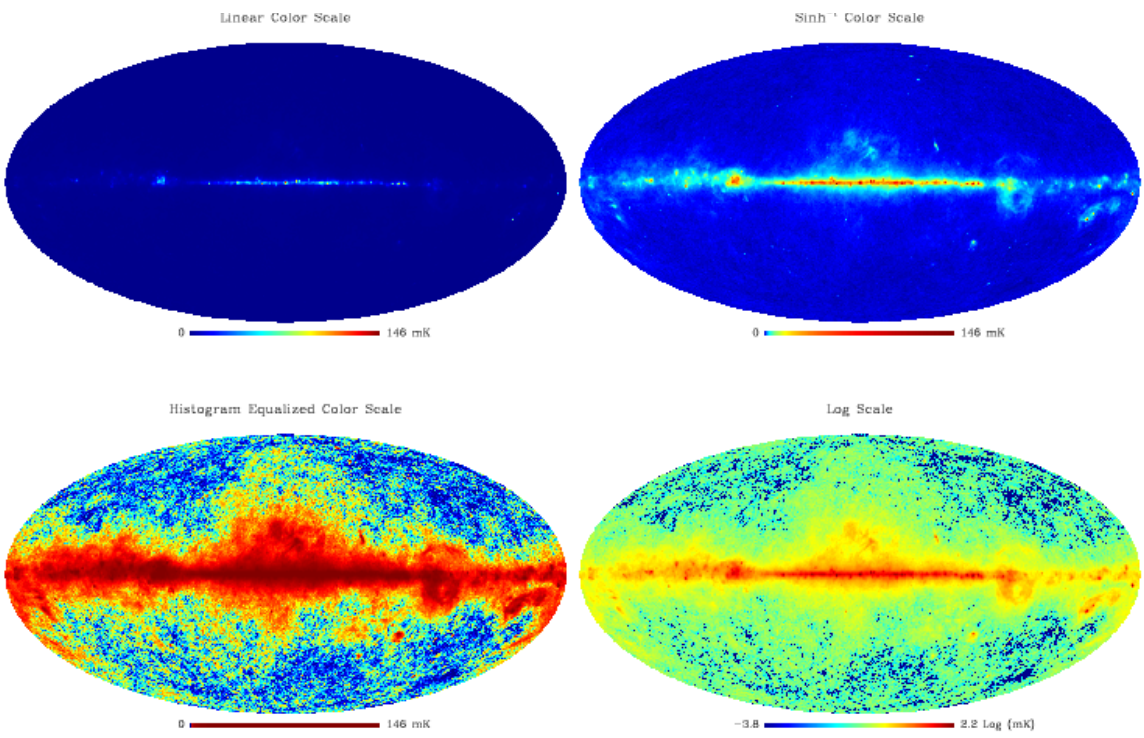

Figure 3: Illustration (generated by Example #5) of the various color scales available.

EXAMPLES: #6

```
mollview, 'HFI_SkyMap_217_2048_R1.10_nominal.fits', $
     colt='planck2', asinh=2, factor=1.e6, offset=-1.33e-4, $
     min=-1.e3, max=1.e7, title='Planck @ 217GHz', charsize=2
```

Illustrates the application of the second color table created by planck_colors to the visualization of Planck data at 217GHz (see Fig. 4 on page 124)

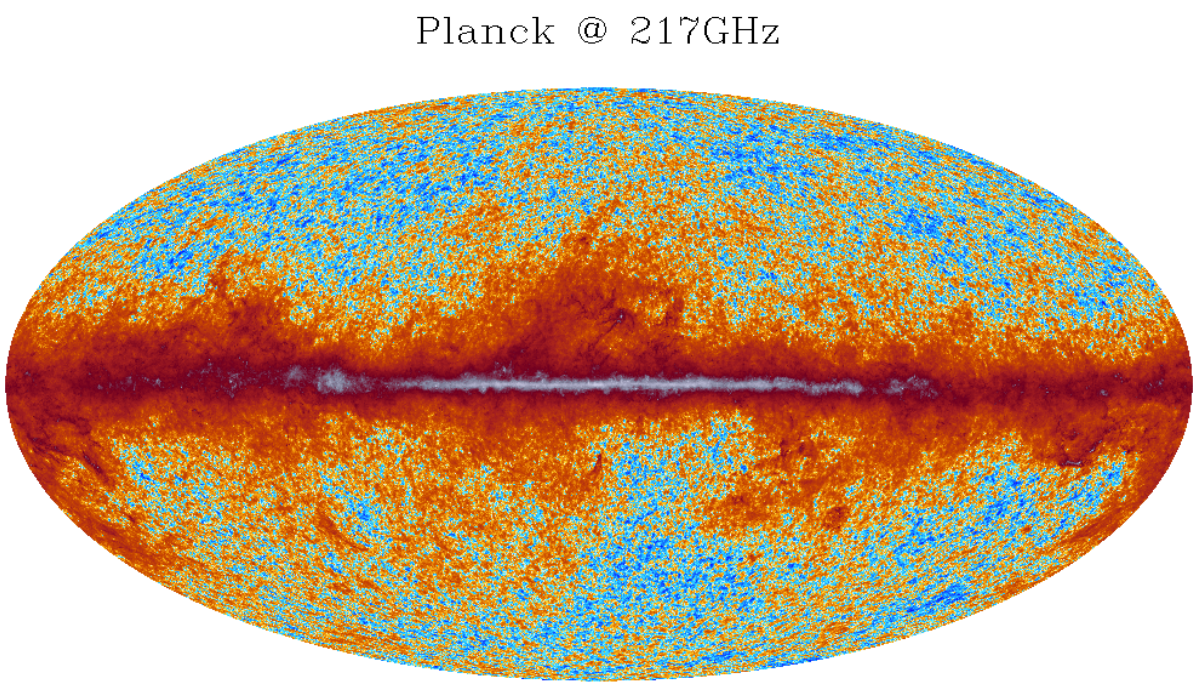

Figure 4: Illustration (generated by Example #6) of the application of Planck color table #2 to a Planck sky map.

EXAMPLES: #7

```
mollview, findgen(12), silhouette=2, default_settings=dsmoll,$
     title='Wider, thicker color bar; left justified title',$
     customize={cbar:{dx:2/3.,dy:1/32.,ty:0.005,box:2},$
          title:{x:0,charsize:2}}
help_st, dsmoll
```

will generate a silhouetted Mollweide projection plot with customized thickness and length of a boxed color bar, and modified location of the title (see Fig. 5 on page 125). The default value (in the Mollweide projection) of the available customization parameters is also listed as

```
** Structure <.....>, 7 tags, length=128, data length=122, refs=1:
  .ASPOS.X              FLOAT    -1.00000
  .ASPOS.Y              FLOAT    -1.00000
  .CBAR.DX              FLOAT    0.333333
  .CBAR.DY              FLOAT    0.0142857
  .CBAR.SPACES          STRING   Array[3]
  .CBAR.TY              FLOAT    0.00000
  .CBAR.BOX             FLOAT    0.00000
  .CRING.DX             FLOAT    0.100000
  .CRING.XLL            FLOAT    0.0250000
  .CRING.YLL            FLOAT    0.0250000
  .PDF.DEBUG            INT      0
  .SUBTITLE.X           FLOAT    0.500000
  .SUBTITLE.Y           FLOAT    0.905000
  .SUBTITLE.CHARSIZE    FLOAT    1.20000
  .TITLE.X              FLOAT    0.500000
  .TITLE.Y              FLOAT    0.950000
  .TITLE.CHARSIZE       FLOAT    1.60000
  .VSCALE.X             FLOAT    0.0500000
  .VSCALE.Y             FLOAT    0.0200000
  .VSCALE.TY            FLOAT    0.00000
```

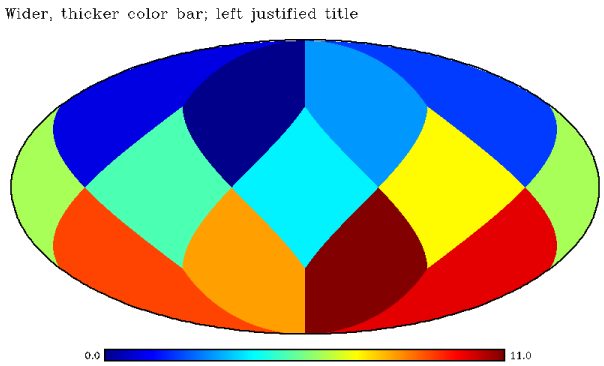

Figure 5: Illustration (generated by Example #7) of customization of the title (size and location) and of the color bar (size and box), and overplotting of a silhouette around the project map.

neighbours_nest

Location in HEALPix directory tree: src/idl/toolkit/neighbours_nest.pro

This IDL facility returns the number and indices of the topological immediate neighbours of a central pixel. The pixels are ordered in a clockwise sense (when watching the sphere from the outside) about the central pixel with the southernmost pixel in first element. For the four pixels in the southern corners of the equatorial faces which have two equally southern neighbours the routine returns the southwestern pixel first and proceeds clockwise.

FORMAT

IDL> neighbours_nest (Nside, Ipix0, Listpix[,Nneigh])

QUALIFIERS

Nside	**HEALPix** resolution parameter (scalar integer), should be a valid Nside (power of 2)
Ipix0	NESTED-scheme index of central pixel in [0,12*Nside^2-1]
Listpix	output: list of neighbouring pixel (NESTED scheme index) of size `Nneigh`
Nneigh	optional output: number of neighbours of pixel `#Ipix0`. Usually 8, sometimes 7 (for 8 particular pixels) or 6 (if Nside=1)

DESCRIPTION

neighbours_nest calls `pix2xy_nest` to find location of central pixel within the pixelation base-face, and then `xy2pix_nest` to find neighbouring pixels within the same face, or one of the bit manipulation routines if the neighbouring pixel is on a different base-face.

RELATED ROUTINES

This section lists the routines related to **neighbours_nest**.

idl	version 6.4 or more is necessary to run neighbours_nest .
neighbours_ring	returns topological immediate neighbouring pixels of a given central pixel, using RING indexing.
query_disc, query_polygon, query_strip, query_triangle	render the list of pixels enclosed respectively in a given disc, polygon, latitude strip and triangle
nest2ring, ring2nest	conversion between NESTED and RING indices

EXAMPLE:

```
neighbours_nest , 4, 1, list, nneigh
print,nneigh,list
```

will return:8 90 0 2 3 6 4 94 91, listing the NESTED-indexed 8 neighbors of pixel #1 for Nside=4

neighbours_ring

Location in HEALPix directory tree: src/idl/toolkit/neighbours_ring.pro

This IDL facility returns the number and indices of the topological immediate neighbours of a central pixel. The pixels are ordered in a clockwise sense (when watching the sphere from the outside) about the central pixel with the southernmost pixel in first element. For the four pixels in the southern corners of the equatorial faces which have two equally southern neighbours the routine returns the southwestern pixel first and proceeds clockwise.

FORMAT

IDL> neighbours_ring (Nside, Ipix0, Listpix[,Nneigh])

QUALIFIERS

Nside	**HEALPix** resolution parameter (scalar integer), should be a valid Nside (power of 2)
Ipix0	RING-scheme index of central pixel in [0,12*Nside^2-1]
Listpix	output: list of neighbouring pixel (RING scheme index) of size `Nneigh`
Nneigh	optional output: number of neighbours of pixel `#Ipix0`. Usually 8, sometimes 7 (for 8 particular pixels) or 6 (if Nside=1)

DESCRIPTION

neighbours_ring calls ring2nest, neighbours_nest and nest2ring

RELATED ROUTINES

This section lists the routines related to **neighbours_ring**.

idl	version 6.4 or more is necessary to run neighbours_ring .

neighbours_nest	returns topological immediate neighbouring pixels of a given central pixel, using NESTED indexing.
query_disc, query_polygon, query_strip, query_triangle	render the list of pixels enclosed respectively in a given disc, polygon, latitude strip and triangle
nest2ring, ring2nest	conversion between NESTED and RING indices

EXAMPLE:

```
neighbours_ring , 4, 1, list, nneigh
print,nneigh,list
```

will return:8 16 6 5 0 3 2 8 7 listing the RING-indexed 8 neighbors of pixel #1 for Nside=4

nest2uniq

Location in HEALPix directory tree: src/idl/toolkit/nest2uniq.pro

This IDL facility turns $N_{\rm side}$ and (NESTED) pixel index into the Unique Identifier .

FORMAT

IDL> nest2uniq, Nside, Pnest, Puniq [,/HELP]

QUALIFIERS

Nside	(IN, scalar or vector Integer) The **HEALPix** $N_{\rm side}$ parameter(s)
Pnest	(IN, scalar or vector Integer) (NESTED scheme) pixel identification number(s) in the range $\{0,12N_{\rm side}^2-1\}$. If `Nside` is a scalar, `Pnest` can a be a scalar or a vector, if `Nside` is a vector, `Pnest` must be a vector of the same size
Puniq	(OUT, same size as `Pnest`) The **HEALPix** Unique pixel identifier(s).

KEYWORDS

/HELP	If set, a documentation header is printed out, and the routine exits

DESCRIPTION

nest2uniq turns the parameter $N_{\rm side}$ (a power of 2) and the pixel index p into the Unique ID number $u = p + 4N_{\rm side}^2$. See "The Unique Identifier scheme" section in "**HEALPix** Introduction Document" for more details.

EXAMPLE:

```
nest2uniq, [1, 2, 4], [0, 0, 0], puniq
print, puniq
```

returns
4 16 64
since the first pixels ($p = 0$) at $N_{\rm side} = 1$, 2 and 4 are respectively the pixels with Unique ID numbers 4, 16 and 64.

RELATED ROUTINES

This section lists the routines related to **nest2uniq**.

uniq2nest	Transforms Unique **HEALPix** pixel ID number into Nside and Nested pixel number
pix2xxx,...	to turn NESTED pixel index into sky coordinates and back

npix2nside

Location in HEALPix directory tree: src/idl/toolkit/npix2nside.pro

This IDL facility provides the **HEALPix** resolution parameter Nside corresponding to Npix pixels over the full sky.

FORMAT

IDL> Nside=NPIX2NSIDE (Npix[,ERROR=])

QUALIFIERS

Npix	number of pixels over the full sky (scalar integer), should be a valid Npix ($N_{\rm pix} = 12N_{\rm side}^2$ with $N_{\rm side}$ power of 2 in $\{1, \ldots, 2^{29}\}$)
Nside	on output: resolution parameter if Npix is valid, -1 otherwise

KEYWORDS

ERROR=	error flag, set to 1 on output if Npix is NOT valid, or stays to 0 otherwise.

DESCRIPTION

npix2nside checks that the given Npix is valid ($N_{\rm pix} = 12N_{\rm side}^2$ with $N_{\rm side}$ a power of 2 in $\{1, \ldots, 2^{29}\}$) and then computes the corresponding resolution parameter $N_{\rm side}$.

RELATED ROUTINES

This section lists the routines related to **npix2nside** .

idl	version 6.4 or more is necessary to run npix2nside .
nside2npix	computes Npix corresponding to Nside
pix2xxx, ang2xxx, vec2xxx, ...	conversion between vector or angles and pixel index and vice-versa

vec2pix, pix2vec	conversion between vector and pixel index
nest2ring, ring2nest	conversion between NESTED and RING indices

EXAMPLE:

```
Nside = npix2nside(49152, ERROR=error)
```

Nside will be 64 because 49152 is a valid pixel number (=12*64^2 and 64 is a power of 2), and error will be 0

EXAMPLE:

```
Nside = npix2nside(49151, ERROR=error)
```

Nside will be -1 and error: 1, because 49151 is not a valid number of **HEALPix** pixels over the full sky.

nside2npix

Location in HEALPix directory tree: src/idl/toolkit/nside2npix.pro

This IDL facility provides the number of pixels $N_{\rm pix}$ over the full sky corresponding to resolution parameter $N_{\rm side}$.

FORMAT

IDL> Npix=NSIDE2NPIX (Nside[, ERROR=, /HELP])

QUALIFIERS

Nside	**HEALPix** resolution parameter (integer, scalar or not), should be a valid $N_{\rm side}$ (power of $2 \leq 2^{29}$)
Npix	number of pixels, same size as Nside, $N_{\rm pix} = 12N_{\rm side}^2$ if $N_{\rm side}$ is a valid resolution parameter or -1 otherwise

KEYWORDS

ERROR=	error flag, set to 1 on output if Nside is NOT valid, or stays to 0 otherwise.
/HELP	if set on input, the documentation header is printed, and the routine exits (with a returned value of -1 and an error flag set to 0).

DESCRIPTION

nside2npix checks that the given Nside is valid (power of 2 in $\{1, \ldots, 2^{29}\}$) and then computes the corresponding number of pixels $N_{\rm pix} = 12N_{\rm side}^2$.

RELATED ROUTINES

This section lists the routines related to **nside2npix**.

idl	version 6.4 or more is necessary to run nside2npix.
npix2nside	computes Nside corresponding to Npix

pix2xxx, ang2xxx, vec2xxx, ...	conversion between vector or angles and pixel index and vice-versa
vec2pix, pix2vec	conversion between vector and pixel index
nest2ring, ring2nest	conversion between NESTED and RING indices

EXAMPLE:

```
Npix = nside2npix(256, ERROR=error)
```

Npix will be 786432 the number of pixels over the full sky for the **HEALPix** resolution parameter 256 and error will be 0

EXAMPLE:

```
Npix = nside2npix(248, ERROR=error)
```

Npix will be -1 and error: 1, because 248 is not a valid value for a **HEALPix** resolution parameter

nside2npweights

Location in HEALPix directory tree: src/idl/toolkit/nside2npweights.pro

This IDL facility provides the number pixel-based quadrature weights (in compact non-redundant form) for a given resolution parameter Nside. Because of the **HEALPix** layout symmetries, $N_w \simeq N_{\rm pix}/16$, allowing economical storage on disc.

FORMAT

IDL> Npweights=NSIDE2NPWEIGHTS (Nside [,ERROR=, /HELP])

QUALIFIERS

Nside	**HEALPix** resolution parameter (integer, scalar or not), should be a valid Nside (power of 2 in $\{1, \ldots, 2^{29}\}$)
Npweights	number of non-redundant weights

KEYWORDS

ERROR=	error flag, set to 1 on output if Nside is NOT valid, or stays to 0 otherwise.
/HELP	if set on input, the documentation header is printed out and the routine exits

DESCRIPTION

nside2npweights outputs the number of different pixel-based weights

$$N_w = \frac{(N_{\rm side}+1)(3N_{\rm side}+1)}{4}.$$

If the argument $N_{\rm side}$ is not valid, a warning is issued and the error flag is raised.

RELATED ROUTINES

This section lists the routines related to **nside2npweights**.

idl	version 6.4 or more is necessary to run nside2npweights .
unfold_weights	generates a full sky map of pixel-based or ring-based quadrature weights

EXAMPLE:

```
Npweights = nside2npweights(256, ERROR=error)
```

Npweights will be 49408 the number of pixel-based weights for the **HEALPix** resolution parameter 256 and error will be 0

nside2ntemplates

Location in HEALPix directory tree: src/idl/toolkit/nside2ntemplates.pro

This IDL facility provides the number of template pixels Ntemplates corresponding to resolution parameter Nside. Each template pixel has a different shape that *can not* be matched (by rotation or reflexion) to that of any of the other templates.

FORMAT

IDL> Ntemplates=NSIDE2NTEMPLATES(Nside[,ERROR=])

QUALIFIERS

Nside	**HEALPix** resolution parameter (integer, scalar or not), should be a valid Nside (power of 2 in $\{1, \ldots, 2^{29}\}$)
Ntemplates	number of templates

KEYWORDS

ERROR=	error flag, set to 1 on output if Nside is NOT valid, or stays to 0 otherwise.

DESCRIPTION

nside2ntemplates outputs the number of template pixels

$$N_{\text{template}} = \frac{1 + N_{\text{side}}(N_{\text{side}} + 6)}{4}.$$

If the argument N_{side} is not valid, a warning is issued and the error flag is raised.

RELATED ROUTINES

This section lists the routines related to **nside2ntemplates**.

idl	version 6.4 or more is necessary to run nside2ntemplates .

template_pixel_ring	
template_pixel_nest	return the template pixel associated with any **HEALPix** pixel
same_shape_pixels_ring	
same_shape_pixels_nest	return the ordered list of pixels having the same shape as a given pixel template

EXAMPLE:

```
Ntemplates = nside2ntemplates(256, ERROR=error)
```

Ntemplates will be 16768 the number of template pixels for the **HEALPix** resolution parameter 256 and error will be 0

orthcursor

Location in HEALPix directory tree: src/idl/visu/orthcursor.pro

This IDL facility provides a point-and-click interface for finding the astronomical location, value and pixel index of the pixels nearest to the pointed position on a orthographic projection of a **HEALPix** map.

FORMAT

IDL> ORTHCURSOR, [cursor_type=, file_out=]

QUALIFIERS

see mollcursor

DESCRIPTION

orthcursor should be called immediately after orthview. It gives the longitude, latitude, map value and pixel number corresponding to the cursor position in the window containing the map generated by orthview. For more details, or in case of problems under **Mac OS X**, see mollcursor.

RELATED ROUTINES

This section lists the routines related to **orthcursor**.

see mollcursor

EXAMPLE:

```
orthcursor
```

After orthview has read in a map and generated its orthographic projection, orthcursor is run to determine the position and flux of bright synchrotron sources, for example.

orthview

Location in HEALPix directory tree: src/idl/visu/orthview.pro

This IDL facility provides a means to visualise a full sky or half sky orthographic projection (projection onto a tangent plane from a point located at infinity) of **HEALPix** and COBE Quad-Cube maps in an IDL environment. It also offers the possibility to generate GIF, JPEG, PDF, PNG and Postscript color-coded images of the projected map. The projected (but not color-coded) data can also be output in FITS files and IDL arrays.

FORMAT

IDL> ORTHVIEW, File [, Select] [, ASINH=, BAD_COLOR=, BG_COLOR=, CHARSIZE=, CHARTHICK=, COLT=, COORD=, /CROP, CUSTOMIZE=, DEFAULT_SETTINGS=, EXECUTE=, FACTOR=, FG_COLOR=, FITS=, /FLIP, GAL_CUT=, GIF=, GLSIZE=, GRATICULE=, /HALF_SKY, HBOUND=, /HELP, /HIST_EQUAL, HXSIZE=, IGLSIZE=, IGRATICULE=, JPEG=, LATEX=, /LOG, MAP_OUT=, MAX=, MIN=, /NESTED, /NO_DIPOLE, /NO_MONOPOLE, /NOBAR, /NOLABELS, /NOPOSITION, OFFSET=, OUTLINE=, PDF=, PFONTS=, PNG=, POLARIZATION=, /PREVIEW, PS=, PXSIZE=, PYSIZE=, RESO_ARCMIN=, RETAIN=, ROT=, /SAVE, /SHADED, /SILENT, SILHOUETTE=, STAGGER=, SUBTITLE=, TITLEPLOT=, TRANSPARENT=, TRUECOLORS=, UNITS=, WINDOW=, XPOS=, YPOS=]

QUALIFIERS

For a full list of qualifiers see mollview

KEYWORDS

For a full list of keywords see mollview

DESCRIPTION

orthview reads in a **HEALPix** sky map in FITS format and generates an orthographic projection of it, that can be visualized on the screen or exported in a GIF, JPEG, PNG, PDF or Postscript file. orthview allows the selection of the coordinate system, map size, color table, color bar inclusion, linear, log, hybrid or histogram equalised color scaling, maximum and minimum range for the plot, plot-title *etc.* It also allows the representation of the polarization field.

RELATED ROUTINES

This section lists the routines related to **orthview**.

see mollview

EXAMPLE:

```
map = findgen(48)
triangle= create_struct('coord','G','ra',[0,80,0],'dec',[40,45,65])
orthview,map,/online,graticule=[45,30],rot=[10,20,30],$
   title='Orthographic projection',subtitle='orthview' $
   outline=triangle
```

makes an orthographic projection of map (see Figure 1d on page 122) after an arbitrary rotation, with a graticule grid (with a 45^o step in longitude and 30^o in latitude) and an arbitrary triangular outline

pix2xxx, ang2xxx, vec2xxx, nest2ring, ring2nest

Location in HEALPix directory tree: src/idl/toolkit/

These routines provide conversion between pixel number in the **HEALPix** map and (θ, ϕ) or (x, y, z) coordinates on the sphere. Some of these routines are listed here.

QUALIFIERS

name (dim.)	type	in/out	description
nside	scalar integer	IN	$N_{\rm side}$ parameter for the **HEALPix** map.
ipnest(n)	vector integer	—	pixel identification number in NESTED scheme over the range $\{0,N_{\rm pix}-1\}$.
ipring(n)	vector integer	—	pixel identification number in RING scheme over the range $\{0,N_{\rm pix}-1\}$.
theta(n)	vector double	—	colatitude in radians measured southward from north pole in $\{0,\pi\}$
phi(n)	vector double	—	longitude in radians, measured eastward in $\{0,2\pi\}$.
vector(n,3)	array double	—	three dimensional cartesian position vector (x, y, z). The north pole is $(0, 0, 1)$. An output vector is normalised to unity. The coordinates are ordered as follows $x(0), \ldots, x(n-1),\ y(0), \ldots, y(n-1),\ z(0), \ldots, z(n-1)$
vertex(n,3,4)	array double	optional OUT	three dimensional cartesian position vector (x, y, z). Contains the location of the four vertices (=corners) of a pixel in the order North, West, South, East. The coordinates are ordered as follows $x_N(0), \ldots, x_N(n-1),\ y_N(0), \ldots, y_N(n-1),\ z_N(0), \ldots, z_N(n-1), x_W(0), \ldots, x_W(n-1),\ y_W(0), \ldots, y_W(n-1),\ z_W(0), \ldots, z_W(n-1)$, and so on with South and East vertices

ROUTINES:

`pix2ang_ring, nside, ipring, theta, phi`

renders `theta` and `phi` coordinates of the nominal pixel center given the pixel number `ipring` and a map resolution parameter `nside`.

`pix2vec_ring, nside, ipring, vector [,vertex]`

renders cartesian vector coordinates of the nominal pixel center given the pixel number `ipring` and a map resolution parameter `nside`. Optionally returns the location of the 4 vertices for the pixel(s) under consideration

`ang2pix_ring, nside, theta, phi, ipring`

renders the pixel number `ipring` for a pixel which, given the map resolution parameter `nside`, contains the point on the sphere at angular coordinates `theta` and `phi`.

`vec2pix_ring, nside, vector, ipring`

renders the pixel number `ipring` for a pixel which, given the map resolution parameter `nside`, contains the point on the sphere at cartesian coordinates `vector`.

`pix2ang_nest, nside, ipnest, theta, phi`

renders `theta` and `phi` coordinates of the nominal pixel center given the pixel number `ipnest` and a map resolution parameter `nside`.

`pix2vec_nest, nside, ipnest, vector [,vertex]`

renders cartesian vector coordinates of the nominal pixel center given the pixel number `ipnest` and a map resolution parameter `nside`. Optionally returns the location of the 4 vertices for the pixel(s) under consideration

`ang2pix_nest, nside, theta, phi, ipnest`

renders the pixel number `ipnest` for a pixel which, given the map resolution parameter `nside`, contains the point on the sphere at angular coordinates `theta` and `phi`.

`vec2pix_nest, nside, vector, ipnest`

renders the pixel number `ipnest` for a pixel which, given the map resolution parameter `nside`, contains the point on the sphere at cartesian coordinates `vector`.

`nest2ring, nside, ipnest, ipring`

performs conversion from NESTED to RING pixel number.

`ring2nest, nside, ipring, ipnest`

performs conversion from RING to NESTED pixel number.

RELATED ROUTINES

This section lists the routines related to **pix2xxx, ang2xxx, vec2xxx, nest2ring, ring2nest**.

idl	version 6.4 or more is necessary to run pix2xxx, ang2xxx,... .
npix2nside	computes $N_{\rm side}$ (resolution) corresponding to Npix (total pixel number)
nside2npix	computes $N_{\rm pix}$ corresponding to $N_{\rm side}$
ang2vec, vec2ang	geometrical conversion between position angles and position vector
nest2uniq, uniq2nest	conversion of standard pixel index to/from Unique ID number

EXAMPLE:

```
pix2ang_ring, 256, [17,1000], theta, phi
print,theta,phi
```

returns
0.0095683558 0.070182078
2.8797933 5.4620872
position of the two pixels #17 and 1000 in the RING scheme with parameter $N_{\rm side}$ =256.

planck_colors

Location in HEALPix directory tree: src/idl/visu/planck_colors.pro

This IDL facility provides RGB color tables suitable for visualization of sky maps dominated by CMB or featuring foreground, and modify current color table. Those color tables can then be implemented in cartview, gnomview, mollview or orthview and were used in Planck 2013 publications

FORMAT

IDL> PLANCK_COLORS, option, [GET=rgb, /HELP, /SHOW]

QUALIFIERS

option — required input for color table generation, must be either 1 or 2:
1: creates the 'parchment' Blue-red color table suitable for maps dominated by Gaussian signal (eg, CMB)
2: creates a Blue-red-white color table suitable for maps with high dynamic signal (eg, Galactic foreground)

KEYWORDS

GET=rgb — optional ouput, contains the newly created RGB color table in a [256, 3] array

/HELP — if set, prints extended help

/SHOW — if set, the chosen color table is shown in a new window

DESCRIPTION

planck_colors creates a set of RGB color tables suitable for specific purpose, and modify the current IDL color table accordingly (using TVLCT). See below the example applications. The created color table can also be output as a 256*3 array, or shown in a new window

RELATED ROUTINES

This section lists the routines related to **planck_colors**.

idl	version 6.4 or more is necessary to run planck_colors.
cartview, gnomview	
mollview, orthview	visualization routines that can make use of the color tables created in planck_colors (via keyword `colt`)
loadct	IDL routine to set current color table to one of the predefined IDL color tables (thus reverting the effect of planck_colors).

EXAMPLE:

```
planck_colors, 1, /show
planck_colors, 2, /show
```

Create and show the two color tables (see Fig. 6 on page 147)

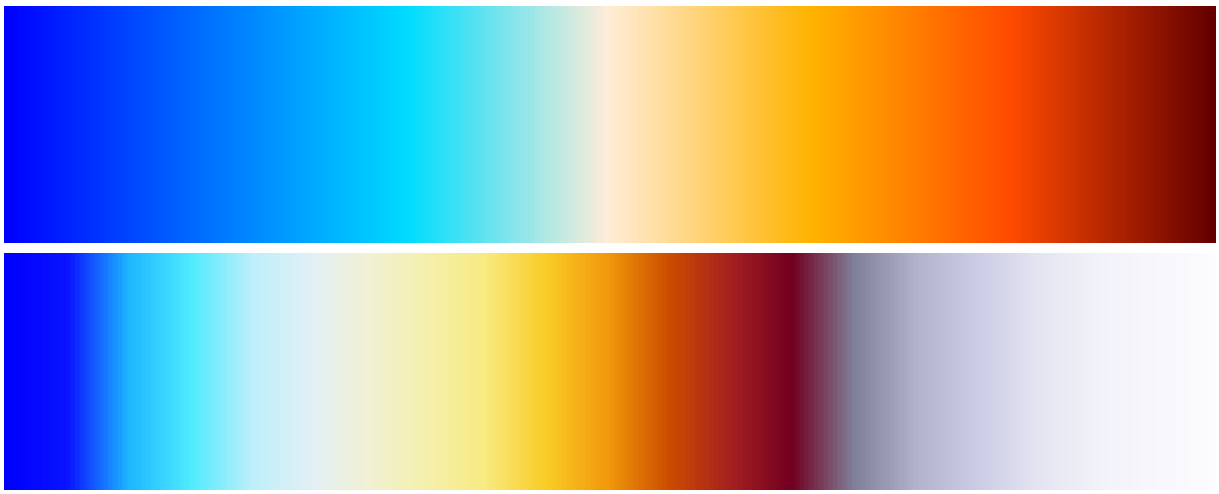

Figure 6: Illustration of the color tables created by planck_colors.

query_disc

Location in HEALPix directory tree: **src/idl/toolkit/query_disc.pro**

This IDL facility provides a means to find the index of all pixels within an angular distance `Radius` from a defined center.

FORMAT

IDL> query_disc , Nside, Vector0, Radius, Listpix, [Nlist, /DEG, /NESTED, /INCLUSIVE]

QUALIFIERS

Nside	**HEALPix** resolution parameter used to index the pixel list (scalar integer)
Vector0	position vector of the disc center (3 elements vector) NB : the norm of Vector0 does not have to be one, what is consider is the intersection of the sphere with the line of direction Vector0.
Radius	radius of the disc (in radians, unless DEG is set), (scalar real)
Listpix	on output: list of ordered index for the pixels found within a radius Radius of the position defined by vector0. The RING numbering scheme is used unless the keyword `NESTED` is set. (=-1 if the radius is too small and no pixel is found)
Nlist	on output: number of pixels in Listpix (=0 if no pixel is found).

KEYWORDS

/DEG	if set `Radius` is in degrees instead of radians
/NESTED	if set, the output list uses the NESTED numbering scheme instead of the default RING
/INCLUSIVE	if set, all the pixels overlapping (even partially) with the disc are listed, otherwise only those whose center lies within the disc are listed

DESCRIPTION

query_disc finds the pixels within the given disc in a selective way WITHOUT scanning all the sky pixels. The numbering scheme of the output list and the inclusiveness of the disc can be changed

RELATED ROUTINES

This section lists the routines related to **query_disc** .

idl	version 6.4 or more is necessary to run query_disc .
ang2pix, pix2ang	conversion between angles and pixel index
vec2pix, pix2vec	conversion between vector and pixel index
query_disc, query_polygon, query_strip, query_triangle	render the list of pixels enclosed respectively in a given disc, polygon, latitude strip and triangle

EXAMPLE:

```
query_disc , 256L, [.5,.5,0.], 10., listpix, nlist, /Deg, /Nest
```

On return listpix contains the index of the (5982) pixels within 10 degrees from the point on the sphere having the direction [.5,.5,0.]. The pixel indices correspond to the Nested scheme with resolution 256.

query_polygon

Location in HEALPix directory tree: src/idl/toolkit/query_polygon.pro

This IDL facility provides a means to find the index of all pixels belonging to a sperical polygon defined by its vertices

FORMAT

IDL> query_polygon , Nside, Vlist, Listpix, [Nlist, HELP=, NESTED=, INCLUSIVE=]

QUALIFIERS

Nside	**HEALPix** resolution parameter used to index the pixel list (scalar integer)
Vlist	3D cartesian position vector of the polygon vertices. Array of dimension (n,3) where n is the number of vertices
Listpix	on output: list of ordered index for the pixels found in the polygon. The RING numbering scheme is used unless the keyword `NESTED` is set. (=-1 if the polygon is too small and no pixel is found)
Nlist	on output: number of pixels in Listpix (=0 if no pixel is found).

KEYWORDS

HELP=	if set, the documentation header is printed out and the routine exits
NESTED=	if set, the output list uses the NESTED numbering scheme instead of the default RING
INCLUSIVE=	if set, all the pixels overlapping (even partially) with the polygon are listed, otherwise only those whose center lies within the polygon are listed

DESCRIPTION

query_polygon finds the pixels within the given polygon in a selective way WITHOUT scanning all the sky pixels. The polygon should be convex, or have only one concave vertex. The edges should not intersect each other. The numbering scheme of the output list and the inclusiveness of the polygon can be changed

RELATED ROUTINES

This section lists the routines related to **query_polygon** .

idl	version 6.4 or more is necessary to run query_polygon .
ang2pix, pix2ang	conversion between angles and pixel index
vec2pix, pix2vec	conversion between vector and pixel index
query_disc, query_polygon, query_strip, query_triangle	render the list of pixels enclosed respectively in a given disc, polygon, latitude strip and triangle

EXAMPLE:

```
query_polygon , 256L, [[0,1,1,0],[0,0,1,1],[1,0,-1,0]], listpix, nlist
```

On return listpix contains the index of the (131191) pixels contained in the polygon with vertices of cartesian coordinates (0,0,1), (1,0,0), (1,1,-1) and (0,1,0). The pixel indices correspond to the RING scheme with resolution 256.

query_strip

Location in HEALPix directory tree: src/idl/toolkit/query_strip.pro

This IDL facility provides a means to find the index of all pixels belonging to a latitude strip defined by its bounds

FORMAT

IDL> query_strip , Nside, Theta1, Theta2, Listpix, [Nlist, NESTED=, INCLUSIVE=, HELP=]

QUALIFIERS

Nside	**HEALPix** resolution parameter used to index the pixel list (scalar integer)
Theta1	colatitude lower bound in radians measured from North Pole (between 0 and π).
Theta2	colatitude upper bound in radians measured from North Pole (between 0 and π). If theta1< theta2, the pixels lying in [theta1,theta2] are output, otherwise, the pixel lying in [0, theta2] and those lying in [theta1, π] are output.
Listpix	on output: list of ordered index for the pixels found in the strip. The RING numbering scheme is used unless the keyword `NESTED` is set. (=-1 if the strip is too small and no pixel is found)
Nlist	on output: number of pixels in Listpix (=0 if no pixel is found).

KEYWORDS

NESTED=	if set, the output list uses the NESTED numbering scheme instead of the default RING
INCLUSIVE=	if set, all the pixels overlapping (even partially) with the strip are listed, otherwise only those whose center lies within the strip are listed

/HELP	if set, the routine prints its documentation header and exits.

DESCRIPTION

query_strip finds the pixels within the given strip in a selective way WITHOUT scanning all the sky pixels. The numbering scheme of the output list and the inclusiveness of the strip can be changed

RELATED ROUTINES

This section lists the routines related to **query_strip** .

idl	version 6.4 or more is necessary to run query_strip .
ang2pix, pix2ang	conversion between angles and pixel index
vec2pix, pix2vec	conversion between vector and pixel index
query_disc, query_polygon, query_triangle	render the list of pixels enclosed respectively in a given disc, polygon and triangle

EXAMPLE:

```
query_strip , 256, 0.75*!PI, !PI/5, listpix, nlist, /nest
```

Returns the NESTED pixel index of all pixels with colatitude in $[0,\pi/5]$ and those with colatitude in $[3\pi/4,\pi]$

query_triangle

Location in HEALPix directory tree: **src/idl/toolkit/query_triangle.pro**

This IDL facility provides a means to find the index of all pixels belonging to a sperical triangle defined by its vertices

FORMAT

IDL> query_triangle , Nside, Vector1, Vector2, Vector3, Listpix, [Nlist, NESTED=, INCLUSIVE=]

QUALIFIERS

Nside	**HEALPix** resolution parameter used to index the pixel list (scalar integer)
Vector1	3D cartesian position vector of the triangle first vertex
Vector2	3D cartesian position vector of the triangle second vertex
Vector3	3D cartesian position vector of the triangle third vertex NB : the norm of Vector* does not have to be one, what is considered is the intersection of the sphere with the line of direction Vector*.
Listpix	on output: list of ordered index for the pixels found in the triangle. The RING numbering scheme is used unless the keyword `NESTED` is set. (=-1 if the triangle is too small and no pixel is found)
Nlist	on output: number of pixels in Listpix (=0 if no pixel is found).

KEYWORDS

NESTED=	if set, the output list uses the NESTED numbering scheme instead of the default RING
INCLUSIVE=	if set, all the pixels overlapping (even partially) with the triangle are listed, otherwise only those whose center lies within the triangle are listed

DESCRIPTION

query_triangle finds the pixels within the given triangle in a selective way WITHOUT scanning all the sky pixels. The numbering scheme of the output list and the inclusiveness of the triangle can be changed

RELATED ROUTINES

This section lists the routines related to **query_triangle** .

idl	version 6.4 or more is necessary to run query_triangle .
ang2pix, pix2ang	conversion between angles and pixel index
vec2pix, pix2vec	conversion between vector and pixel index
query_disc, query_polygon, query_strip, query_triangle	render the list of pixels enclosed respectively in a given disc, polygon, latitude strip and triangle

EXAMPLE:

```
query_triangle , 256L, [1,0,0],[0,1,0],[0,0,1], listpix, nlist
```

On return listpix contains the index of the (98560) pixels lying in the octant $(x > 0, y > 0, y > 0)$. The pixel indices correspond to the RING scheme with resolution 256.

read_fits_cut4

Location in HEALPix directory tree: src/idl/fits/read_fits_cut4.pro

This IDL facility reads a cut sky **HEALPix** map from a FITS file according to the **HEALPix** convention. The format used for the FITS file follows the one used for Boomerang98 and is adapted from COBE/DMR. This routine can also be used to read polarized cut sky map, where each Stokes parameter is stored in a different extension of the same FITS file.

FORMAT

IDL> READ_FITS_CUT4 , File, Pixel, Signal[, N_Obs, Serror, EXTENSION=, HDR=, XHDR=, NSIDE=, ORDERING=, COORDSYS=, HELP=]

QUALIFIERS

File	name of a FITS file in which the map is to be written
Pixel	(OUT, LONG vector), index of observed (or valid) pixels
Signal	(OUT, FLOAT vector), value of signal in each observed pixel
N_Obs	(OUT, LONG or INT vector, Optional), number of observation per pixel
Serror	(OUT, FLOAT vector, Optional), *rms* of signal in pixel. For white noise, this is $\propto 1/\sqrt{\text{n\_obs}}$

KEYWORDS

EXTENSION=	(IN, optional), 0 based number of extension to read. Extension 0 contains the temperature information, while extensions 1 and 2 contain respectively the Q and U Stokes parameters related information. (**default:** 0)

HDR= (OUT, optional),
String array containing the primary header.

XHDR= (OUT, optional),
String array containing the extension header.

NSIDE= (OUT, optional),
returns on output the **HEALPix** resolution parameter, as read from the FITS header. Set to -1 if not found

ORDERING= (OUT, optional),
returns on output the pixel ordering, as read from the FITS header. Either 'RING' or 'NESTED' or ' ' (if not found).

COORDSYS= (OUT, optional),
returns on output the astrophysical coordinate system used, as read from FITS header (value of keywords COORDSYS or SKYCOORD)

HELP= (IN, optional),
if set, an extensive help is displayed, and no file is read

DESCRIPTION

RELATED ROUTINES

This section lists the routines related to **read_fits_cut4** .

idl — version 6.4 or more is necessary to run read_fits_cut4

write_fits_cut4 — This **HEALPix** IDL facility can be used to generate the FITS format *cut-sky* maps complient with **HEALPix** convention and readable by read_fits_cut4 .

read_fits_cut4, read_fits_map
read_tqu, read_fits_s — **HEALPix** IDL routines to read cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets from FITS files

sxpar — This IDL routine (included in **HEALPix** package) can be used to extract FITS keywords

from the header(s) HDR or XHDR read with read_fits_cut4 .

read_fits_map

Location in HEALPix directory tree: src/idl/fits/read_fits_map.pro

This IDL facility reads in a **HEALPix** map from a FITS file.

FORMAT

IDL> READ_FITS_MAP , File, T_sky, [Hdr, Exthdr, PIXEL=, SILENT=, NSIDE=, ORDERING=, COORDSYS=, EXTENSION=, HELP=]

QUALIFIERS

File	name of a FITS file containing the **HEALPix** map in an extension or in the image field
T_sky	variable containing on output the **HEALPix** map
Hdr	(optional), string variable containing on output the FITS primary header
Exthdr	(optional), string variable containing on output the FITS extension header
PIXEL=	(optional), pixel number to read from or pixel range to read (in the order of appearance in the file), starting from 0. if ≥ 0 scalar : read from pixel to the end of the file if two elements array : reads from pixel[0] to pixel[1] (included) if absent : read the whole file
NSIDE=	(optional), returns on output the **HEALPix** resolution parameter, as read from the FITS header. Set to -1 if not found
ORDERING=	(optional), returns on output the pixel ordering, as read from

the FITS header. Either 'RING' or 'NESTED' or ' ' (if not found).

COORDSYS= (optional),
returns on output the astrophysical coordinate system used, as read from FITS header (value of keywords COORDSYS or SKYCOORD)

EXTENSION= (optional),
extension unit to be read from FITS file: either its 0-based ID number (ie, 0 for first extension *after* primary array) or the case-insensitive value of its EXTNAME keyword. If absent, all available extensions are read.

KEYWORDS

HELP= if set, an extensive help is displayed and no file is read

SILENT= if set, no message is issued during normal execution

DESCRIPTION

read_fits_map reads in a **HEALPix** sky map from a FITS file, and outputs the variable `T_sky`, where the optional variables `Hdr` and `Exthdr` contain respectively the primary and extension headers. According to **HEALPix** convention, the map should be is stored as a FITS file binary table extension. Note:the routine read_tqu which requires less memory is recommended when reading *large polarized* maps.

RELATED ROUTINES

This section lists the routines related to **read_fits_map**.

idl version 6.4 or more is necessary to run read_fits_map

read_fits_cut4, read_fits_map

read_tqu, read_fits_s **HEALPix** IDL routines to read cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets from FITS files

sxpar	This IDL routine (included in **HEALPix** package) can be used to extract FITS keywords from the header(s) `Hdr` or `Exthdr` read with read_fits_map.
synfast	This **HEALPix** facility will generate the FITS format sky map that can be read by read_fits_map.
write_fits_map	This **HEALPix** IDL facility can be used to generate the FITS format sky maps complient with **HEALPix** convention and readable by read_fits_map.

EXAMPLE:

```
read_fits_map, 'planck100GHZ-LFI.fits', map, hdr, xhdr, /silent
```

read_fits_map reads in the file 'planck100GHZ-LFI.fits' and outputs the **HEALPix** map in `map`, the primary header in `hdr` and the extension header in `xhdr`.

read_fits_s

Location in HEALPix directory tree: src/idl/fits/read_fits_s.pro

This IDL facility reads a FITS file into an IDL structure.

FORMAT

IDL> READ_FITS_S , File, Prim_stc, [Xten_stc, COLUMNS=, EXTENSION=, /HELP, /MERGE]

QUALIFIERS

File	name of a FITS file containing the healpix map(s) in an extension or in the image field
Prim_stc	variable containing on output an IDL structure with the following fields: - primary header (tag : 0, tag name : HDR) - primary image (if any, tag : 1, tag name : IMG)
Xten_stc	(optional), variable containing on output an IDL structure with the following fields: - extension header (tag : 0, tag name : HDR) - data column 1 (if any, tag : 1, tag name given by TTYPE1 (with all spaces removed and only letters, digits and underscore) - data column 2 (if any, tag : 2, tag name given by TTYPE2) ...
COLUMNS=	(optional), list of columns to be read from a binary table can be a list of integer (1 based) indexing the columns positions or a list of names matching the TTYPE* of the columns by default, all columns are read
EXTENSION=	(optional), extension unit to be read from FITS file: either its 0-based ID number (ie, 0 for first extension *after* primary array) or the case-insensitive value of its EXTNAME keyword. (**default:** 0)

KEYWORDS

/HELP	if set, an extensive help is displayed and no file is read
/MERGE	if set `Prim_stc` contains : - the concatenated primary and extension header (tag name : HDR) - primary image (if any, tag name : IMG) - data column 1 ... and `Exten_stc` is set to 0 (**default:** :) not set (or set to 0)

DESCRIPTION

read_fits_s reads in any type of FITS file (Image, Binary table or Ascii table) and outputs the data in IDL structures

RELATED ROUTINES

This section lists the routines related to **read_fits_s** .

idl	version 6.4 or more is necessary to run read_fits_s
synfast	This **HEALPix** facility will generate the FITS format sky map that can be read by read_fits_s .
read_fits_cut4, read_fits_map read_tqu, read_fits_s	**HEALPix** IDL routines to read cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets from FITS files
write_fits_sb	This **HEALPix** IDL facility can be used to generate FITS format sky maps readable by read_fits_s .

EXAMPLE:

```
read_fits_s , 'dmr_skymap_90a_4yr.fits', pdata, xdata
```

read_fits_s reads in the file 'dmr_skymap_90a_4yr.fits'. On output, pdata contains the primary header and xdata is a structure whose first field is the extension header, and the other fields are vectors with respective tag names PIXEL, SIGNAL, N_OBS, SERROR, ... (see `help,/struc,xdata`)

read_tqu

Location in HEALPix directory tree: src/idl/fits/read_tqu.pro

This IDL facility reads a temperature+polarization Healpix map (T,Q,U) from a binary table FITS file, with optionally the error (dT,dQ,dU) and correlation (dQU, dTU, dTQ) from separate extensions

FORMAT

IDL> READ_TQU , File, TQU, [Extension=, Hdr=, Xhdr=, /HELP, Nside=, Ordering=, Coordsys=]

QUALIFIERS

File — name of a FITS file from which the maps are to be read

TQU — : array of Healpix maps of size ($N_{\rm pix}$,3,`n_ext`) where $N_{\rm pix}$ is the total number of Healpix pixels on the sky, and `n_ext` ≤ 3 is the number of extensions read
Three maps are available in each extension of the FITS file :
-the temperature+polarization Stokes parameters maps (T,Q,U) in extension 0
-the error maps (dT,dQ,dU) in extension 1 (if applicable)
-the correlation maps (dQU, dTU, dTQ) in extension 2 (if applicable)

Extension= — (optional),
extension unit to be read from FITS file: either its 0-based ID number (ie, 0 for first extension *after* primary array) or the case-insensitive value of its EXTNAME keyword. If absent, all available extensions are read.

Hdr= — (optional),
string variable containing on output the contents of the primary header. (If already present, FITS reserved keywords will be automatically updated).

Xhdr=	(optional), string variable containing on output the contents of the extension header. If several extensions are read, then the extension headers are returned appended into one string array.
Nside=	(optional), returns on output the **HEALPix** resolution parameter, as read from the FITS header. Set to -1 if not found
Ordering=	(optional), returns on output the pixel ordering, as read from the FITS header. Either 'RING' or 'NESTED' or ' ' (if not found).
Coordsys=	(optional), returns on output the astrophysical coordinate system used, as read from FITS header (value of keywords COORDSYS or SKYCOORD)

KEYWORDS

/HELP	if set, an extensive help is displayed and no file is read

DESCRIPTION

read_tqu reads out Stokes parameters (T,Q,U) maps for the whole sky into a FITS file. It is also possible to read the error per pixel for each map and the correlation between fields, as subsequent extensions of the same FITS file (see qualifiers above). Therefore the file may have up to three extensions with three maps in each. Extensions can be written together or one by one (in their physical order) using the Extension option

RELATED ROUTINES

This section lists the routines related to **read_tqu**.

idl	version 6.4 or more is necessary to run read_tqu
synfast	This **HEALPix** f90 facility can be used to generate temperature+polarization maps that can be read with read_tqu

write_tqu	This **HEALPix** IDL facility can be used to write out temperature+polarization that can be read by read_tqu.
read_fits_cut4, read_fits_map	
read_tqu, read_fits_s	**HEALPix** IDL routines to read cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets from FITS files
read_fits_s	This general purpose **HEALPix** IDL facility can be used to read into an IDL structure maps contained in binary table FITS files.
sxpar	This IDL routine (included in **HEALPix** package) can be used to extract FITS keywords from the header(s) HDR or XHDR read with read_tqu.

EXAMPLE:

```
read_tqu, 'map_polarization.fits', TQU, xhdr=xhdr
```

Reads into `TQU` the polarization maps contained in the FITS file 'map_polarization.fits'. The variable `xhdr` will contain the extension(s) header.

remove_dipole

Location in HEALPix directory tree: **src/idl/misc/remove_dipole.pro**

This IDL facility provides a means to fit and remove the dipole and monopole from a **HEALPix** map.

FORMAT

IDL> REMOVE_DIPOLE, Map [, Weight, BAD_DATA=, GAL_CUT=, COORD_IN=, COORD_OUT=, Covariance_Matrix=, Dipole=, Monopole=, /NOREMOVE, NSIDE=, /ONLYMONOPOLE, ORDERING=, PIXEL=, /SILENT, UNITS=, /HELP]

QUALIFIERS

Map
: input and output, vector
map from which monopole and dipole are to be removed (also used for output). Assumed to be a full sky data set, unless PIXEL is set and has the same size as map

Weight
: input, vector, optional
same size as map, describe weighting scheme to apply to each pixel for the fit
(**default:** uniform weight)

BAD_DATA =
: scalar float, value given on input to bad pixels
(**default:** `!healpix.bad_value` $\equiv -1.6375\ 10^{30}$).

GAL_CUT=
: if set to a value larger than 0, the pixels with galactic latitude $|b|$ <gal_cut degrees are not considered in the fit.
NB: the cut is *really* done in Galactic coordinates. If the input coordinates are different (see Coord_In), the map is rotated into galactic before applying the cut.

COORD_IN =
: string, map coordinate system (either 'Q' or 'C': equatorial, 'G': galactic or 'E': ecliptic; upper/lower case accepted)

	(**default:** 'G' (galactic))
COORD_OUT =	string, coordinate system (see above) in which to output dipole vector in variable Dipole (**default:** same as coord_in)
Covariance_Matrix =	OUTPUT, scalar (or symmetric 4x4 matrix), covariance of the statistical errors made on monopole (and dipole) determination
Dipole=	OUTPUT, 3d vector, coordinates of best fit dipole (done simultaneously with monopole), same units as input map
Monopole=	OUTPUT, scalar float, value found for the best fit monopole (done simultaneously with dipole), same units as input map
NSIDE=	scalar integer, healpix resolution parameter
ORDERING=	string, ordering scheme (either 'RING' or 'NESTED')
PIXEL=	input, vector, gives the Healpix index of the pixels whose temperature is actually given in map (for cut sky maps). If present, must match Map in size. If absent, it is assumed that the map covers the whole sky.
UNITS=	string, units of the input map

KEYWORDS

/NOREMOVE	if set, the best fit dipole and monopole are computed but not removed (ie, Map is unchanged)
/ONLYMONOPOLE	if set, fit (and remove) only the monopole
/HELP	if set, only display documentation header
/SILENT	if set, the routine works silently

DESCRIPTION

remove_dipolemakes a simultaneous least square fit of the monopole and dipole on all the valid pixels of Map (those with a value different from BAD_DATA) with a galactic latitude larger in magnitude than GAL_CUT (in degrees). The position of the pixels on the sky is reconstructed from NSIDE and ORDERING. If Map does not cover the full sky, the actual indices of the concerned pixels should be given in PIXEL

RELATED ROUTINES

This section lists the routines related to **remove_dipole**.

idl	version 6.4 or more is necessary to run remove_dipole.

reorder

Location in HEALPix directory tree: src/idl/toolkit/reorder.pro

This IDL facility allows the reordering of a full sky map from NESTED to RING scheme and vice-versa.

FORMAT

IDL> Result = REORDER (Input_map [, /HELP, In=, Out=, /N2R, /R2N])

QUALIFIERS

Result	variable containing on output the reordered map
Input_map	variable containing the input map

KEYWORDS

/HELP	if set, the documentation header is printed out and the code exits
In=	specifies the input ordering, can be either 'RING' or 'NESTED'
Out=	specifies the output ordering, can be either 'RING' or 'NESTED'
/N2R	If set, does the NESTED to RING conversion, equivalent to In='NESTED' and Out='RING'
/R2N	If set, does the RING to NESTED conversion, equivalent to In='RING' and Out='NESTED'

DESCRIPTION

reorder allows the reordering of a full sky map from NESTED to RING scheme and vice-versa

RELATED ROUTINES

This section lists the routines related to **reorder** .

idl	version 6.4 or more is necessary to run reorder

ud_grade	downgrades or prograde a full-sky or cut-sky **HEALPix** map.

EXAMPLE:

```
map_nest = reorder(map_ring, in='ring', out='nest')
```

The RING ordered map `map_ring` is converted to the NESTED map `map_nest`.

rotate_coord

Location in HEALPix directory tree: src/idl/misc/rotate_coord.pro

This IDL facility provides a means to rotate a set of 3D position vectors (and their Stokes parameters Q and U) between to astrophysical coordinate systems or by an arbitrary rotation.

FORMAT

IDL> Outvec = rotate_coord(Invec [, Delta_Psi=, Euler_Matrix=, Inco=, Outco=, Stokes_Parameters=, /free_norm, /help])

QUALIFIERS

Invec	input, array of size (n,3) : set of 3D position vectors
Outvec	output, array of size (n,3) : rotated 3D vectors, with the same norms as the input vectors
Delta_Psi	output, vector of size (n) containing the change in azimuth $\Delta\psi$ in Radians resulting from the rotation (measured with respect to the local meridian, from South to East), so that for field of spin s the output Q', U' is related to the input Q, U via $Q' = Q\cos(s\Delta\psi) - U\sin(s\Delta\psi)$, $U' = U\cos(s\Delta\psi) + Q\sin(s\Delta\psi)$, with $s = 2$ for polarization Stokes parameters (for which the specific Stokes_Parameters is also available).
Euler_Matrix=	input, array of size (3,3). Euler Matrix describing the rotation to apply to vectors. (**default:** identity : no rotation). Can *not* be used together with a change in coordinates.
Inco=	input, character string (either 'Q' or 'C': equatorial, 'G': galactic or 'E': ecliptic) describing the input coordinate system
Outco=	input, character string (see above) describing the output coordinate system. Can not be used together with Euler_Matrix

Stokes_Parameters= — input and output, array of size (n, 2) : values of the Q and U Stokes parameters on the sphere for each of the input position vector. Q and U are defined wrt the local meridian and parallel and are therefore transformed in a non-trivial way in case of rotation

KEYWORDS

/free_norm — if set (and Stokes_Parameters and/or Delta_Psi are present) the input (and output) coordinate vectors are *not* assumed to be normalized to 1. Using this option is therefore safer, but 20 to 30% slower. (Note that 3D vectors produced by `ang2vec`, `pix2vec_nest` and `pix2vec_ring` *are* properly normalized). Ignored when Stokes_Parameters and Delta_Psi are both absent.

/help — if set, the documentation header is printed and the routine exits

DESCRIPTION

rotate_coord is a generalisation of the Astro library routine `skyconv`. It allows a rotation of 3D position vectors between two standard astronomic coordinates system but also an arbitrary active rotation described by its Euler Matrix. It can also compute how the linear polarization Stokes parameters (Q and U, expressed in local coordinates system) of each input location are affected by the solid body rotation, or equivalently it can output the corresponding change in azimuth.

RELATED ROUTINES

This section lists the routines related to **rotate_coord**.

idl — version 6.4 or more is necessary to run rotate_coord.

euler_matrix_new — constructs the Euler Matrix for a set of three angles and three axes of rotation

`ang2vec`, `pix2vec_*` — can be used to generate the input 3D vectors

same_shape_pixels_nest & same_shape_pixels_ring

Location in HEALPix directory tree: src/idl/toolkit/same_shape_pixels_nest.pro, src/idl/toolkit/same_shape_pixels_ring.pro

These IDL facilities provide the ordered list of all **HEALPix** pixels having the same shape as a given template, for a resolution parameter $N_{\rm side}$.

FORMAT

IDL> same_shape_pixels_nest, Nside, Template, List_Pixels_Nest [, Reflexion, NREPLICATIONS=]

IDL> same_shape_pixels_ring, Nside, Template, List_Pixels_Ring [, Reflexion, NREPLICATIONS=]

QUALIFIERS

Nside	(IN, scalar) the **HEALPix** $N_{\rm side}$ parameter.
Template	(IN, scalar) identification number of the template (this number is independent of the numbering scheme considered).
List_Pixels_Nest	(OUT, vector) ordered list of NESTED scheme identification numbers for all pixels having the same shape as the template provided
List_Pixels_Ring	(OUT, vector) ordered list of RING scheme identification numbers for all pixels having the same shape as the template provided
Reflexion	(OUT, OPTIONAL, vector) in {0, 3} encodes the transformation(s) to apply to each of the returned pixels to match exactly in shape and position the template provided. 0: rotation around the polar axis only, 1: rotation + East-West swap (ie, reflexion around meridian), 2: rotation + North-South

swap (ie, reflexion around Equator), 3: rotation + East-West and North-South swaps

KEYWORDS

NREPLICATIONS — (OUT, OPTIONAL, scalar) number of pixels having the same shape as the template. It is also the length of the vectors `List_Pixel_Nest`, `List_Pixel_Ring` and `Reflexion`. It is either 8, 16, $4N_{\rm side}$ or $8N_{\rm side}$.

DESCRIPTION

same_shape_pixels_nest & same_shape_pixels_ring provide the ordered list of all **HEALPix** pixels having the same shape as a given template, for a resolution parameter $N_{\rm side}$. Depending on the template considered the number of such pixels is either 8, 16, $4N_{\rm side}$ or $8N_{\rm side}$. The template pixels are all located in the Northern Hemisphere, or on the Equator. They are chosen to have their center located at

$$\begin{aligned} z = \cos(\theta) \geq 2/3, \qquad & 0 < \phi \leq \pi/2, \\ 2/3 > z \geq 0, \qquad & \phi = 0, \quad \text{or} \quad \phi = \frac{\pi}{4N_{\rm side}}. \end{aligned} \tag{7}$$

They are numbered continuously from 0, starting at the North Pole, with the index increasing in ϕ, and then increasing for decreasing z.

EXAMPLE:

```
same_shape_pixels_ring, 256, 1234, list_pixels, reflexion, nrep=np
```

Returns in `list_pixels` the RING-scheme index of the all the pixels having the same shape as the template #1234 for $N_{\rm side} = 256$. Upon return `reflexion` will contain the reflexions to apply to each pixel returned to match the template, and `np` will contain the number of pixels having that same shape (16 in that case).

RELATED ROUTINES

This section lists the routines related to **same_shape_pixels_nest & same_shape_pixels_ring**.

nside2templates	returns the number of template pixel shapes available for a given $N_{\rm side}$.
template_pixel_ring	
template_pixel_nest	return the template shape matching the pixel provided

template_pixel_nest & template_pixel_ring

Location in HEALPix directory tree: src/idl/toolkit/template_pixel_nest.pro, src/idl/toolkit/template_pixel_ring.pro

These IDL facilities provide the index of the template pixel associated with a given **HEALPix** pixel, for a resolution parameter $N_{\rm side}$.

FORMAT

IDL> template_pixel_nest, Nside, Pixel_Nest, Template, Reflexion

IDL> template_pixel_ring, Nside, Pixel_Ring, Template, Reflexion

QUALIFIERS

Nside	(IN, scalar) the **HEALPix** $N_{\rm side}$ parameter.
Pixel_Nest	(IN, scalar or vector) NESTED scheme pixel identification number(s) over the range $\{0,12N_{\rm side}^2-1\}$.
Pixel_Ring	(IN, scalar or vector) RING scheme pixel identification number(s) over the range $\{0,12N_{\rm side}^2-1\}$.
Template	(OUT, scalar or vector) identification number(s) of the template matching in shape the pixel(s) provided (the numbering scheme of the pixel templates is the same for both routines).
Reflexion	(OUT, scalar or vector) in {0, 3} encodes the transformation(s) to apply to each pixel provided to match exactly in shape and position its respective template. 0: rotation around the polar axis only, 1: rotation + East-West swap (ie, reflexion around meridian), 2: rotation + North-South swap (ie, reflexion around Equator), 3: rotation + East-West and North-South swaps

DESCRIPTION

template_pixel_nest & template_pixel_ring provide the index of the template pixel associated with a given **HEALPix** pixel, for a resolution parameter $N_{\rm side}$.

Any pixel can be *matched in shape* to a single of these templates by a combination of a rotation around the polar axis with reflexion(s) around a meridian and/or the equator.

The template pixels are all located in the Northern Hemisphere, or on the Equator. They are chosen to have their center located at

$$\begin{aligned} z = \cos(\theta) \geq 2/3, \qquad & 0 < \phi \leq \pi/2, \\ 2/3 > z \geq 0, \qquad & \phi = 0, \quad \text{or} \quad \phi = \frac{\pi}{4N_{\rm side}}. \end{aligned} \tag{8}$$

They are numbered continuously from 0, starting at the North Pole, with the index increasing in ϕ, and then increasing for decreasing z.

EXAMPLE:

```
template_pixel_ring, 256, 500000, template, reflexion
```

Returns in `template` the index of the template pixel (16663) whose shape matches that of the pixel #500000 for $N_{\rm side} = 256$. Upon return `reflexion` will contain 2, meaning that the template must be reflected around a meridian and around the equator (and then rotated around the polar axis) in order to match the pixel.

RELATED ROUTINES

This section lists the routines related to **template_pixel_nest & template_pixel_ring**.

nside2templates	returns the number of template pixel shapes available for a given $N_{\rm side}$.
same_shape_pixels_ring	
same_shape_pixels_nest	return the ordered list of pixels having the same shape as a given pixel template

ud_grade

Location in HEALPix directory tree: src/idl/toolkit/ud_grade.pro

This IDL facility provides a means to upgrade/degrade or reorder a full sky or cut-sky **HEALPix** map contained in a FITS file or loaded in memory.

FORMAT

IDL> UD_GRADE, Map_in, Map_out [, BAD_DATA=, HELP=, NSIDE_OUT=, ORDER_IN=, ORDER_OUT=, /PESSIMISTIC]

QUALIFIERS

Map_in — input map: either a character string with the name of a FITS file containing a full-sky or cut-sky Healpix data set, or a memory vector (real, integer, ...) containing a *full sky* data set.

Map_out — reordered map: if map_in was a filename, map_out should be a filename, otherwise map_out should point to a memory array

KEYWORDS

BAD_DATA = — flag value of missing pixels. (**default:** `!healpix.bad_value` $\equiv -1.6375\ 10^{30}$).

/HELP — if set, the documentation header is printed out and the code exits

NSIDE_OUT = — output resolution parameter, can be larger or smaller than the input one (scalar integer). (**default:** same as input: map unchanged or simply reordered)

ORDER_IN = — input map ordering (either 'RING' or 'NESTED') (**default:** same as the input FITS keyword ORDERING if applicable).

ORDER_OUT =	output map ordering (either 'RING' or 'NESTED') (**default:** same as ORDER_IN).
/PESSIMISTIC	if set, during **degradation** each big pixel containing one bad or missing small pixel is also considered as bad, if not set, each big pixel containing at least one good pixel is considered as good (optimistic) default = 0 (:not set)

DESCRIPTION

ud_grade can upgrade/degrade a **HEALPix** map using the hierarchical properties of **HEALPix** . It can also reorder a sky map (from NEST to RING and vice-versa). It operates on FITS files as well as on memory variables. Cut-sky operations are only accessible via FITS files. The degradation/upgradation is done assuming an intensive quantity (like temperature) that does not scale with surface area. In case of degradation a big pixel that contains at least one bad small pixel is considered as bad itself. When operating on FITS files, the header information from the input file that is not directly related the ordering/resolution is copied unchanged into the output file.

RELATED ROUTINES

This section lists the routines related to **ud_grade**.

idl	version 6.4 or more is necessary to run ud_grade.
reorder	reorder a full sky Healpix map.

EXAMPLES: #1

```
ud_grade, 'map_512.fits', 'map_256.fits', nside_out = 256
```

ud_grade reads the FITS file map_512.fits (that allegedly contains a map with NSIDE=512), and write in the FITS file map_256.fits a map degraded to resolution 256, with the same ordering.

EXAMPLES: #2

```
ud_grade, 'map_512.fits', 'map_Nest256.fits', nside_out = 256, $
  order_out = 'NESTED'
```

ud_grade reads the FITS file map_512.fits (that allegedly contains a map with NSIDE=512), and writes in the FITS file map_Nest256.fits a map degraded to resolution 256, with NESTED ordering.

EXAMPLES: #3

```
read_fits_map, 'map_Nest256.fits', mymap
ud_grade, mymap, mymap2, nside_out = 1024, order_in='NESTED', order_out='RING'
```

mymap is IDL variable containing a **HEALPix** NESTED-ordered map with resolution nside=256. ud_grade upgrades this map to a resolution of 1024, reorder it to RING and write it in the IDL vector mymap2.

unfold_weights

Location in HEALPix directory tree: src/idl/toolkit/unfold_weights.pro

This IDL function returns the full sky map of the weights to be applied to a **HEALPix** map in order to improve the quadrature. The input weights can be either ring-based or pixel-based, and read from file with user provided path, or from files with standardized name and location (ie, `!healpix.path.data+'weight_ring_n?????.fits'` and `!healpix.path.data+'weight_pixel_n?????.fits'`

FORMAT

IDL> weight_map = unfold_weights (File, [Dim, /HELP, /SILENT])

IDL> weight_map = unfold_weights (Nside, [Dim, /PIXEL, /RING, SCHEME=, DIRECTORY=, /HELP, /SILENT])

QUALIFIERS

Nside	**HEALPix** resolution parameter (scalar integer), should be a valid Nside (power of 2 in $\{1, \ldots, 2^{29}\}$)
File	Input weight file to be read. If not provided, the function will try to guess the relevant file path based on Nside, the optional DIRECTORY, and the weighting scheme which **must** be set, with either RING, PIXEL or SCHEME
Dim	dimension of output, either 1 or 2. (**default:** 1)
weight_map	output: vector of size $N_{\rm pix} = 12N_{\rm side}^2$ if Dim=1, array of size $(N_{\rm pix}, 3)$ if Dim=2 (in the latter case, all three columns are identical).

KEYWORDS

DIRECTORY=	directory in which to look for the weight file (**default:** !healpix.path.data)

/HELP	if set on input, the documentation header is printed out and the function exits
/PIXEL	if set, the code will look for the pixel-based weight file corresponding the the Nside provided, in the default or provided Directory
/RING	if set, the code will look for the ring-based weight file corresponding the the Nside provided, in the default or provided Directory
SCHEME=	can be either 'PIXEL' or 'RING', setting the type of weight file the code will look for.
/SILENT	if set on input, the function works silently

DESCRIPTION

unfold_weights reads a list of weights, stored in a compact form in a FITS file, and centered on 0, either ring-based (uniform weights on each iso-latitude rings, defined on $2N_{\rm side}$ rings), or pixel-based (defined on $N_w \simeq 0.75N_{\rm side}^2 \simeq N_{\rm pix}/16$) and turns them into a full sky **HEALPix** map of quadrature weights, with RING indexing and with values centered on 1.

RELATED ROUTINES

This section lists the routines related to **unfold_weights**.

idl	version 6.4 or more is necessary to run unfold_weights .
nside2npweights	returns the number of non-redundant pixel-based weights used for disc storage

EXAMPLE:

```
mollview, /hist,
     unfold_weights(256, /ring), title='Ring-based weights @ Nside=256'
mollview, /hist,
     unfold_weights(256, /pixel), title='Pixel-based weights @ Nside=256'
```

will plot the full sky map of the ring-based and pixel-based quadrature weights for $N_{\rm side} = 256$.

uniq2nest

Location in HEALPix directory tree: src/idl/toolkit/uniq2nest.pro

This IDL facility turns the Unique Identifier into the corresponding $N_{\rm side}$ and (NESTED) pixel index.

FORMAT

IDL> uniq2nest, Puniq, Nside, Pnest [,/HELP]

QUALIFIERS

Puniq	(IN, scalar or vector Integer) The **HEALPix** Unique pixel identifier(s). Must be ≥ 4.
Nside	(OUT, same size as `Puniq`) The **HEALPix** $N_{\rm side}$ parameter(s)
Pnest	(OUT, same size as `Puniq`) (NESTED scheme) pixel identification number(s) over the range $\{0,12N_{\rm side}^2 - 1\}$.

KEYWORDS

/HELP	If set, a documentation header is printed out, and the routine exits

DESCRIPTION

uniq2nest turns the Unique ID number $u = p + 4N_{\rm side}^2$, into the parameter $N_{\rm side}$ (a power of 2) and the pixel index p. See "The Unique Identifier scheme" section in "**HEALPix** Introduction Document" for more details.

EXAMPLE:

```
uniq2nest, [4,16, 64], nside, pnest
print, nside, pnest
```

returns
1 2 4
0 0 0
since the pixels with Unique ID numbers 4, 16 and 64 are the first pixels ($p = 0$) at $N_{\rm side} = 1$, 2 and 4 respectively.

RELATED ROUTINES

This section lists the routines related to **uniq2nest**.

nest2uniq	Transforms Nside and Nested pixel number into Unique **HEALPix** pixel ID number
pix2xxx, ...	to turn NESTED pixel index into sky coordinates and back

vec2ang

Location in HEALPix directory tree: src/idl/toolkit/vec2ang.pro

This IDL facility convert the 3D position vectors of points into their angles on the sphere.

FORMAT

IDL> VEC2ANG , Vector, Theta, Phi[, ASTRO=]

QUALIFIERS

Vector — input, array,
three dimensional cartesian position vector (x, y, z) (not necessarily normalised). The north pole is $(0, 0, 1)$. The coordinates are ordered as follows $x(0), \ldots, x(n-1)$, $y(0), \ldots, y(n-1)$, $z(0), \ldots, z(n-1)$

Theta — output, vector,
vector, colatitude in radians measured southward from north pole in [0,π] (mathematical coordinates).
If ASTRO is set, Theta is the latitude in degrees measured northward from the equator, in [-90, 90] (astronomical coordinates).

Phi — output, vector,
longitude in radians measured eastward, in [0, 2π] (mathematical coordinates).
If ASTRO is set, Phi is the longitude in degree measured eastward, in [0,360] (astronomical coordinates).

KEYWORDS

ASTRO= — if set Theta and Phi are the latitude and longitude in degrees (astronomical coordinates) instead of the colatitude and longitude in radians (mathematical coordinates).

DESCRIPTION

vec2ang performs the geometrical transform from the 3D position vectors (x, y, z) of points into their angles (θ, ϕ) on the sphere: $x = \sin\theta\cos\phi$, $y = \sin\theta\sin\phi$, $z = \cos\theta$

RELATED ROUTINES

This section lists the routines related to **vec2ang** .

idl	version 6.4 or more is necessary to run vec2ang .
pix2xxx, ...	conversion between vector or angles and pixel index
ang2vec	conversion from angles to position vectors

EXAMPLE:

write_fits_cut4

Location in HEALPix directory tree: src/idl/fits/write_fits_cut4.pro

This IDL facility writes out a cut sky **HEALPix** map into a FITS file according to the **HEALPix** convention. The format used for the FITS file follows the one used for Boomerang98 and is adapted from COBE/DMR. This routine can be used to store polarized maps, where the information relative to the Stokes parameters I, Q and U are placed in extension 0, 1 and 2 respectively by successive invocation of the routine.

FORMAT

IDL> WRITE_FITS_CUT4 , File, Pixel, Signal[, N_Obs, Serror, COORDSYS=, EXTENSION=, HDR=, /NESTED, NSIDE=, ORDERING=, /POLARISATION, /RING, UNITS=, XHDR=, HELP=]

QUALIFIERS

File	name of a FITS file in which the map is to be written
Pixel	(LONG or LONG64 vector), index of observed (or valid) pixels
Signal	(FLOAT or DOUBLE vector, same size as Pixel), value of signal in each observed pixel
N_Obs	(LONG or INT or LONG64 vector, Optional, same size as Pixel), number of observation per pixel. If absent, the field `N_OBS` will take a value of 1 in the output file. If set to a scalar constant, `N_OBS` will take this value in the output file
Serror	(FLOAT or DOUBLE vector, Optional, same size as Pixel) *rms* of signal in pixel, for white noise, this is $\propto 1/\sqrt{\text{n\_obs}}$ If absent, the field `SERROR` will take a value of

0.0 in the output file. If set to a scalar constant, SERROR will take this value in the output file

KEYWORDS

COORDSYS= (optional),
if set to either 'C', 'E' or 'G', specifies that the Healpix coordinate system is respectively Celestial=equatorial, Ecliptic or Galactic. (The relevant keyword is then added/updated in the extension header, but the map is NOT rotated)

EXTENSION= (optional),
(0 based) extension number in which to write data. (**default:** 0). If set to 0 (or not set) *a new file is written from scratch*. If set to a value larger than 1, the corresponding extension is added or updated, as long as all previous extensions already exist. All extensions of the same file should use the same ORDERING, NSIDE and COORDSYS.

HDR= (optional),
String array containing the information to be put in the primary header.

/NESTED (optional) if set, specifies that the map is in the NESTED ordering scheme
see also: Ordering and Ring

NSIDE= (optional),
scalar integer, **HEALPix** resolution parameter of the data set. The resolution parameter should be made available to the FITS file, either thru this qualifier, or via the header (see XHDR).

ORDERING= (optional),
if set to either 'ring' or 'nested' (case un-sensitive), specifies that the map is respectively in RING or NESTED ordering scheme
see also: Nested and Ring
The ordering information should be made available to the FITS file, either thru a combination of Ordering/Ring/Nested, or via the header (see XHDR).

/POLARISATION specifies that file will contain the I, Q and U polarisation Stokes parameter in extensions 0, 1 and

	2 respectively, and sets the FITS header keywords accordingly
/RING	if set, specifies that the map is in the RING ordering scheme see also: Ordering and Nested
UNITS=	(optional), string describing the physical units of the data set (only applies to Signal and Serror)
XHDR=	(optional), String array containing the information to be put in the extension header.
HELP=	(optional), if set, an extensive help is displayed, and no file is written

DESCRIPTION

RELATED ROUTINES

This section lists the routines related to **write_fits_cut4** .

idl	version 6.4 or more is necessary to run write_fits_cut4
read_fits_cut4	This **HEALPix** IDL facility can be used to read in maps written by write_fits_cut4 .
write_fits_cut4, write_fits_map	
write_tqu, write_fits_sb	**HEALPix** IDL routines to write cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets into FITS files
sxaddpar	This IDL routine (included in **HEALPix** package) can be used to update or add FITS keywords to the header in `HDR` and `XHDR`

EXAMPLES: #1

```
write_fits_cut4 , 'map_cut.fits', pixel, temperature, /ring, nside=32, /pol
```

writes in 'map_cut.fits' a FITS file containing the temperature measured in a set of **HEALPix** pixel.

EXAMPLES: #2

```
write_fits_cut4 , 'tqu_cut.fits', pixel, temperature, n_t, s_t, $
   /ring, nside=32, /pol
write_fits_cut4 , 'tqu_cut.fits', pixel, qstokes, n_q, s_q, $
   /ring, nside=32, /pol, ext=1
write_fits_cut4 , 'tqu_cut.fits', pixel, ustokes, n_u, s_u, $
   /ring, nside=32, /pol, ext=2
```

writes in 'tqu_cut.fits' a FITS file with three extensions, each of them containing information on the observed pixel, the measured signal, the number of observations and noise per pixel, for the three Stokes parameters I, Q and U respectively. The **HEALPix** ring ordered scheme and the resolution $N_{\rm side} = 32$ is assumed.

write_fits_map

Location in HEALPix directory tree: src/idl/fits/write_fits_map.pro

This IDL facility writes out a **HEALPix** map into a FITS file according to the **HEALPix** convention

FORMAT

IDL> WRITE_FITS_MAP, File, T_sky, [Header, Coordsys=, Error=, Help=, Nested=, Ring=, Ordering=, Units=]

QUALIFIERS

File	name of a FITS file in which the map is to be written
T_sky	variable containing the **HEALPix** map
Header	(optional), string variable containing on input the information to be added to the extension header. (If already present, FITS reserved keywords will be automatically updated).
Coordsys=	(optional), if set to either 'C', 'E' or 'G', specifies that the Healpix coordinate system is respectively Celestial=equatorial, Ecliptic or Galactic. (The relevant keyword is then added/updated in the extension header, but the map is NOT rotated)
Error=	(optional output), will take value 1 if file can not be written
Ordering=	(optional), if set to either 'ring' or 'nested' (case un-sensitive), specifies that the map is respectively in RING or NESTED ordering scheme see also: Nested and Ring
Units=	(optional), string describing the physical units of the data set

KEYWORDS

Help	if set, an extensive help is displayed and no file is written
Nested	if set, specifies that the map is in the NESTED ordering scheme see also: Ordering and Ring
Ring	if set, specifies that the map is in the RING ordering scheme see also: Ordering and Nested

DESCRIPTION

write_fits_map writes out the full sky **HEALPix** map `T_sky` into the FITS file `File`. Extra information about the map can be given in `Header` according to the FITS header conventions. Coordinate systems can also be specified by `Coordsys`. Specifying the ordering scheme is compulsary and can be done either in `Header` or by setting `Ordering` or `Nested` or `Ring` to the correct value. If `Ordering` or `Nested` or `Ring` is set, its value overrides what is given in `Header`.

RELATED ROUTINES

This section lists the routines related to **write_fits_map**.

idl	version 6.4 or more is necessary to run write_fits_map
read_fits_map	This **HEALPix** IDL facility can be used to read in maps written by write_fits_map.
sxaddpar	This IDL routine (included in **HEALPix** package) can be used to update or add FITS keywords to `Header`
reorder	This **HEALPix** IDL routine can be used to reorder a map from NESTED scheme to RING scheme and vice-versa.
write_fits_cut4, write_fits_map	
write_tqu, write_fits_sb	**HEALPix** IDL routines to write cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets into FITS files
write_fits_sb	routine to write multi-column binary FITS table

EXAMPLE:

```
write_fits_map, 'file.fits', map, coordsys='G', ordering='ring'
```

write_fits_map writes out the RING ordered map `map` in Galactic coordinates into the file `file.fits`.

write_fits_sb

Location in HEALPix directory tree: src/idl/fits/write_fits_sb.pro

This IDL facility writes out a **HEALPix** map into a FITS file according to the **HEALPix** convention. It can also write an arbitray data set into a FITS binary table

FORMAT

IDL> WRITE_FITS_SB, File, Prim_Stc[, Xten_stc, Coordsys=, /Nested, /Ring, Ordering=, /Partial, Nside=, Extension=, /Nothealpix]

QUALIFIERS

File — name of a FITS file in which the map is to be written

Prim_stc — IDL structure containing the following fields:
- primary header
- primary image

Set it to 0 to get an empty primary unit

Xten_stc — (optional),
IDL structure containing the following fields:
- extension header
- data column 1
- data column 2

...

NB: because of some astron routines limitation, avoid using the single letters 'T' or 'F' as tagnames in the structures Prim_stc and Xten_stc.

KEYWORDS

Coordsys= — (optional),
if set to either 'C', 'E' or 'G', specifies that the Healpix coordinate system is respectively Celestial=equatorial, Ecliptic or Galactic. (The relevant keyword is then added/updated in the ex-

tension header, but the map is NOT rotated)

Ordering= (optional),
if set to either 'ring' or 'nested' (case un-sensitive), specifies that the map is respectively in RING or NESTED ordering scheme
see also: Nested and Ring

Nside= (optional),
scalar integer, **HEALPix** resolution parameter of the data set. Must be used when the data set does not cover the whole sky

Extension= (optional),
scalar integer, extension in which to write the data (0 based).
(**default:** 0)

/Nested (optional),
if set, specifies that the map is in the NESTED ordering scheme
see also: Ordering and Ring

/Ring (optional),
if set, specifies that the map is in the RING ordering scheme
see also: Ordering and Nested

/Partial (optional),
if set, the data set does not cover the whole sky. In that case the information on the actual map resolution should be given by the qualifier Nside (see above), or included in the FITS header enclosed in the Xten_stc.

/Nothealpix (optional),
if set, the data set can be arbitrary, and the restriction on the number of pixels do not apply. The keywords `Ordering`, `Nside`, `Nested`, `Ring` and `Partial` are ignored.

DESCRIPTION

write_fits_sb writes out the information contained in `Prim_stc` and `Exten_stc` in the primary unit and extension of the FITS file `File` respectively . Coordinate systems can also be specified by `Coordsys`. Specifying the ordering scheme is compulsary for **HEALPix** data sets and can be done either in `Header` or by setting `Ordering` or `Nested` or `Ring` to the correct value. If `Ordering` or `Nested` or `Ring` is set, its value overrides what is given in `Header`.

The data is assumed to represent a full sky data set with the number of data points npix = 12*Nside*Nside unless
Partial is set *or* the input FITS header contains OBJECT = 'PARTIAL'
AND
the Nside qualifier is given a valid value *or* the FITS header contains a NSIDE.

In the **HEALPix** scheme, invalid or missing pixels should be given the value `!healpix.bad_value`$= -1.63750\,10^{30}$.

If `Nothealpix` is set, the restrictions on Nside are void.

RELATED ROUTINES

This section lists the routines related to **write_fits_sb**.

idl	version 6.4 or more is necessary to run write_fits_sb
read_fits_map	This **HEALPix** IDL facility can be used to read in maps written by write_fits_sb.
read_fits_s	This **HEALPix** IDL facility can be used to read into an IDL structure maps written by write_fits_sb.
sxaddpar	This IDL routine (included in **HEALPix** package) can be used to update or add FITS keywords to the header in `Prim_stc` and `Exten_stc`
write_fits_cut4, write_fits_map	
write_tqu, write_fits_sb	**HEALPix** IDL routines to write cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets into FITS files

write_tqu — This **HEALPix** IDL facility based on write_fits_sb is designed to write temperature+polarization (T,Q,U) maps

EXAMPLE:

```
npix = nside2npix(128)
f= randomn(seed,npix)
n= lindgen(npix)+3
map_FN = create_struct('HDR',[' '],'FLUX',f,'NUMBER',n)
write_fits_sb, 'map_fluxnumber.fits', 0, map_FN, coord='G', /ring
```

The structure map_FN is defined to contain a fictitious Flux+number map, where one field is a float and the other an integer. write_fits_sb writes out the contents of map_FN into the extension of the FITS file 'map_fluxnumber.fits'.

write_tqu

Location in HEALPix directory tree: src/idl/fits/write_tqu.pro

This IDL facility writes a temperature+polarization Healpix map (T,Q,U) into a binary table FITS file, with optionally the error (dT,dQ,dU) and correlation (dQU, dTU, dTQ) in separate extensions

FORMAT

IDL> WRITE_TQU , File, TQU, [Coordsys=, Nested=, Ring=, Ordering=, Error=, Extension=, Help=, Hdr=, Xhdr=, Units=, Help=]

QUALIFIERS

File — name of a FITS file in which the maps are to be written

TQU — array of Healpix maps of size ($N_{\rm pix}$,3,`n_ext`) where $N_{\rm pix}$ is the total number of Healpix pixels on the sky, and `n_ext` ≤ 3.
Three maps are written in each extension of the FITS file :
-the temperature+polarization Stokes parameters maps (T,Q,U) in extension 0
-the error maps (dT,dQ,dU) (if `n_ext` ≥ 2) in extension 1
-the correlation maps (dQU, dTU, dTQ) (if `n_ext` = 3) in extension 2
it is also possible to write 3 maps directly in a given extension (provided the preceding extension, if any, is already filled in) by setting `Extension` to the extension number in which to write (0 based) and if `n_ext` + `Extension` ≤ 3

Coordsys= — (optional),
if set to either 'C', 'E' or 'G', specifies that the Healpix coordinate system is respectively Celestial=equatorial, Ecliptic or Galactic. (The relevant keyword is then added/updated in the extension header, but the map is NOT rotated)

Error= (optional output),
will take value 1 if file can not be written

Extension= (optional),
extension unit a which to put the data (0 based). The physical interpretation of the maps is determined by the extension in which they are written
see also: TQU

Hdr= (optional),
string variable containing on input the information to be added to the primary header. (If already present, FITS reserved keywords will be automatically updated).

Ordering= (optional),
if set to either 'ring' or 'nested' (case un-sensitive), specifies that the map is respectively in RING or NESTED ordering scheme
see also: Nested and Ring

Units= (optional),
string describing the physical units of the data set

Xhdr= (optional),
string variable containing on input the information to be added to the extension headerx. (If already present, FITS reserved keywords will be automatically updated). It will be repeated in each extension, except for TTYPE* and EXTNAME which are generated by the routine and depend on the extension

KEYWORDS

Help if set, an extensive help is displayed and no file is written

Nested if set, specifies that the map is in the NESTED ordering scheme
see also: Ordering and Ring

Ring if set, specifies that the map is in the RING ordering scheme
see also: Ordering and Nested

DESCRIPTION

write_tqu writes out Stokes parameters (T,Q,U) maps for the whole sky into a FITS file. It is also possible to write the error per pixel for each map and the correlation between fields, as subsequent extensions of the same FITS file (see qualifiers above). Therefore the file may have up to three extensions with three maps in each. Extensions can be written together or one by one (in their physical order) using the Extension option

RELATED ROUTINES

This section lists the routines related to **write_tqu**.

idl	version 6.4 or more is necessary to run write_tqu
read_tqu	This **HEALPix** IDL facility can be used to read in maps written by write_tqu.
read_fits_s	This **HEALPix** IDL facility can be used to read into an IDL structure maps written by write_tqu.
sxaddpar	This IDL routine (included in **HEALPix** package) can be used to update or add FITS keywords to the header(s) HDR or XHDR
write_fits_cut4, write_fits_map write_tqu, write_fits_sb	**HEALPix** IDL routines to write cut-sky maps, full-sky maps, polarized full-sky maps and arbitrary data sets into FITS files

EXAMPLE:

```
npix = nside2npix(64)
TQU = randomn(seed,npix,3)
write_tqu, 'map_polarization.fits', TQU, coord='G', /ring
```

The array TQU is defined to contain a fictitious polarisation map, with the 3 Stokes parameters T, Q and U. The map is assumed to be in Galactic coordinates, with a RING ordering of the pixels and $N_{\rm side} = 64$. write_tqu writes out the contents of TQU into the extension of the FITS file 'map_polarization.fits'.