Getting and Reading Data

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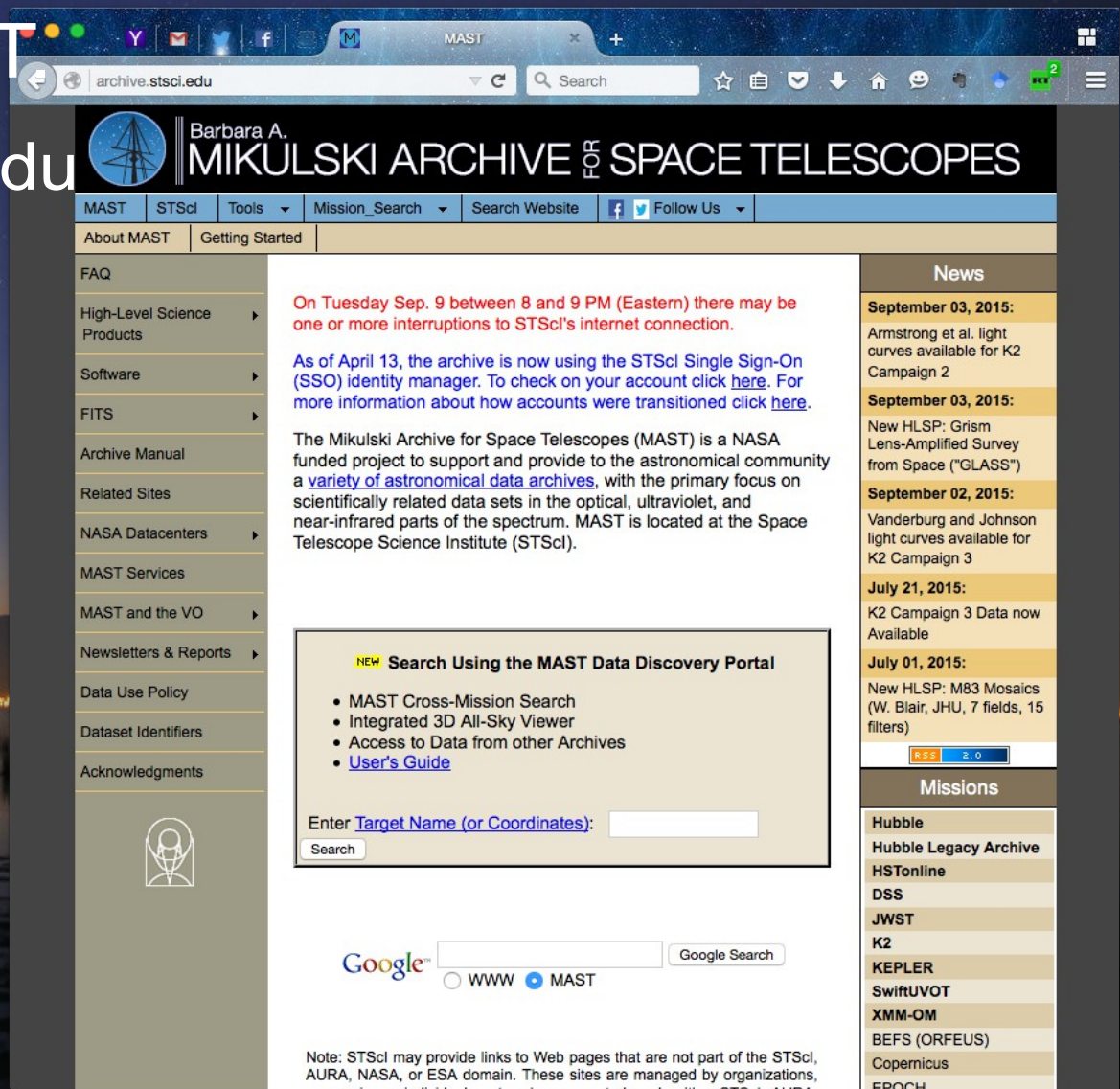
Data Sources

- UV/Optical Data available from MAST
  - http://archive.stsci.edu



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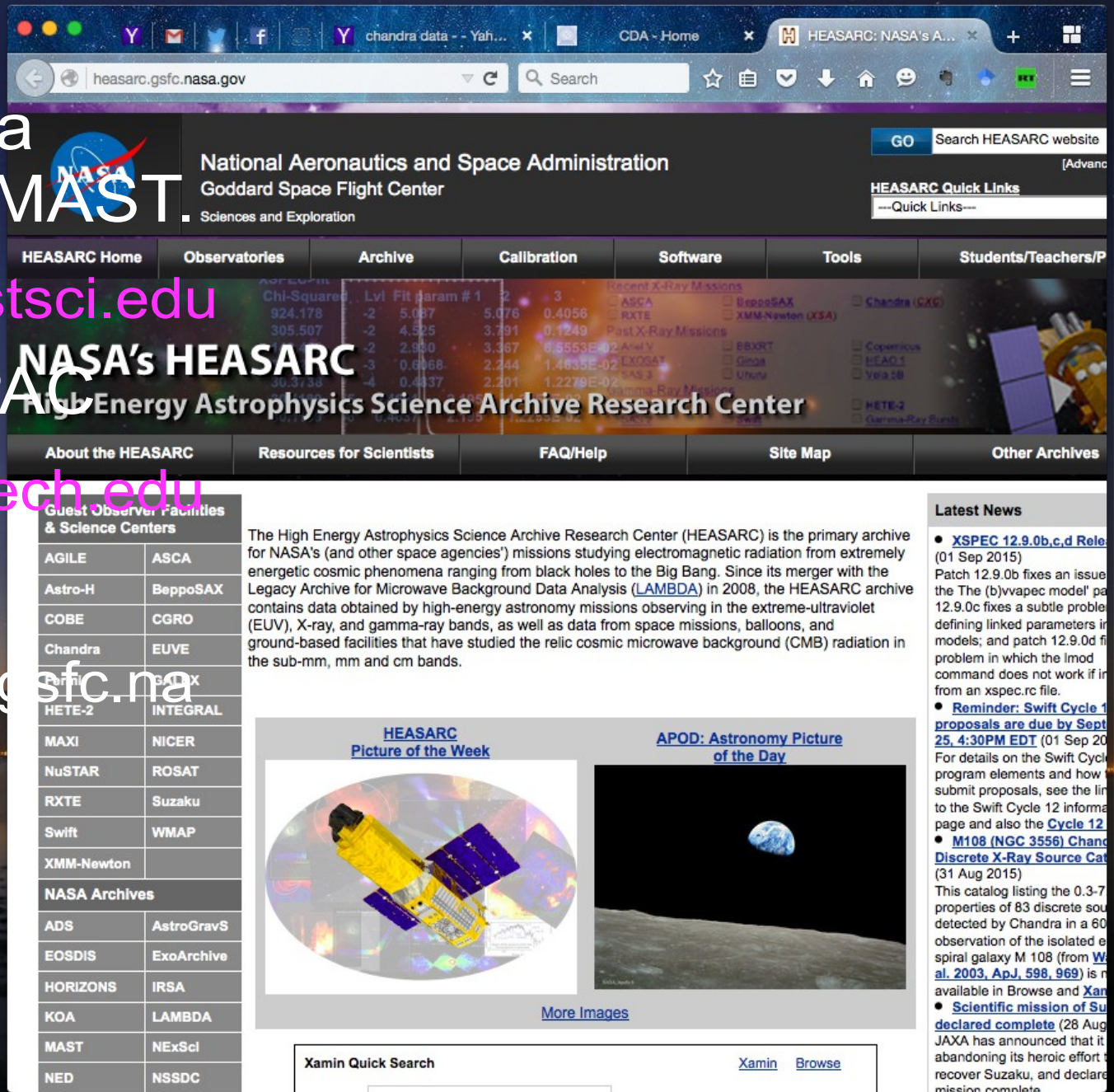
  - http://ipac.caltech.edu
- Heasarc
  - http://heasarc.gsfc.nasa.gov



Flexible Image Transport System

- Maintains scientific data format.
- Self-documenting.
- Quick look data:
  - DS9.
  - FITS Liberator.
  - Aladin.
- *Once FITS, always FITS.*
- FITS software must be able to read all files.
- Standard routines in many languages.
  - CFITSIO for C programs.

Definitions

- Primary HDU.
- Followed by extensions.
- Comprised of an integer number of 2880 8 bit bytes.

```
$listhead hlsp_uv-bkgd_galex_map_allsky_fuv_v1_skymap.fits[0]
Header listing for HDU #1:
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                 3600 / length of data axis 1
NAXIS2  =                 1800 / length of data axis 2
```

```
$listhead hlsp_uv-bkgd_galex_map_allsky_fuv_v1_skymap.fits[1]
Header listing for HDU #2:
XTENSION= 'IMAGE   '           / IMAGE extension
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                 3600 / length of data axis 1
NAXIS2  =                 1800 / length of data axis 2
```

FITS Definitions

- FITS Header:
  - ASCII for quick viewing.
- Keywords: Fields 1 - 8.
  - Upper case letters + numbers + “_” + “-”
- Value: Fields 9 – 10.
  - “=”: Assignment
- If Keyword is COMMENT, remaining text is description.

Mandatory Keywords

- SIMPLE = T / file does conform to FITS standard
- BITPIX = -32 / number of bits per data pixel
- NAXIS = 2 / number of data axes
- NAXIS1 = 3600 / length of data axis 1
- NAXIS2 = 1800 / length of data axis 2
- EXTEND = T / FITS dataset may contain extensions

- SIMPLE: Either T or F. Only found in primary header.

Mandatory Keywords

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BITPIX	
Value	Data Representation
8	Character or unsigned binary integer
16	16-bit twos-complement binary integer
32	32-bit twos-complement binary integer
-32	IEEE single precision floating point
-64	IEEE double precision floating point

Mandatory Keywords

- SIMPLE = T / file does conform to FITS standard
- BITPIX = -32 / number of bits per data pixel
- NAXIS = 2 / number of data axes
- NAXIS1 = 3600 / length of data axis 1
- NAXIS2 = 1800 / length of data axis 2
- EXTEND = T / FITS dataset may contain extensions

- NAXIS = 0 – 999
  - Number of axes in image file.
  - If NAXIS = 0, no data in the extension.
- NAXISn: Number of elements in each axis.

Coordinates

- CRVAL1 = 0. / REF POINT VALUE IN DEGREES
- CRPIX1 = 1800. / REF POINT PIXEL LOCATION
- CDELT1 = -0.1 / DEGREES PER PIXEL
- CROTA1 = 0. / ROTATION FROM ACTUAL AXIS
- CTYPE1 = 'GLON-AIT' / COORDINATE TYPE
- CRVAL2 = 0. / REF POINT VALUE IN DEGREES
- CRPIX2 = 900. / REF POINT PIXEL LOCATION
- CDELT2 = 0.1 / DEGREES PER PIXEL
- CROTA2 = 0. / ROTATION FROM ACTUAL AXIS
- CTYPE2 = 'GLAT-AIT' / COORDINATE TYPE

- CRVAL1, CRVAL2 are the coordinates of CRPIX1 and CRPIX2.
- CDELT1 and CDELT2 are increments per pixel.
- CROTA1 and CROTA2 are rotation angles.
- CTYPE1, CTYPE2 are projections.

Projections

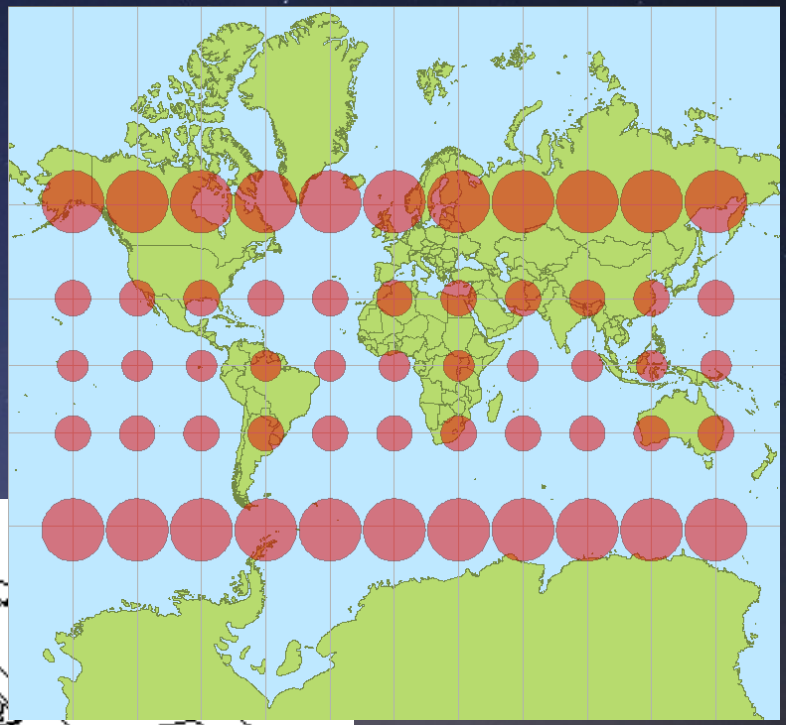
- GLON, GLAT
- RA--, DEC-
- ELON, ELAT, HLON, HLAT, SLON, SLAT
- -AIT
- -TAN

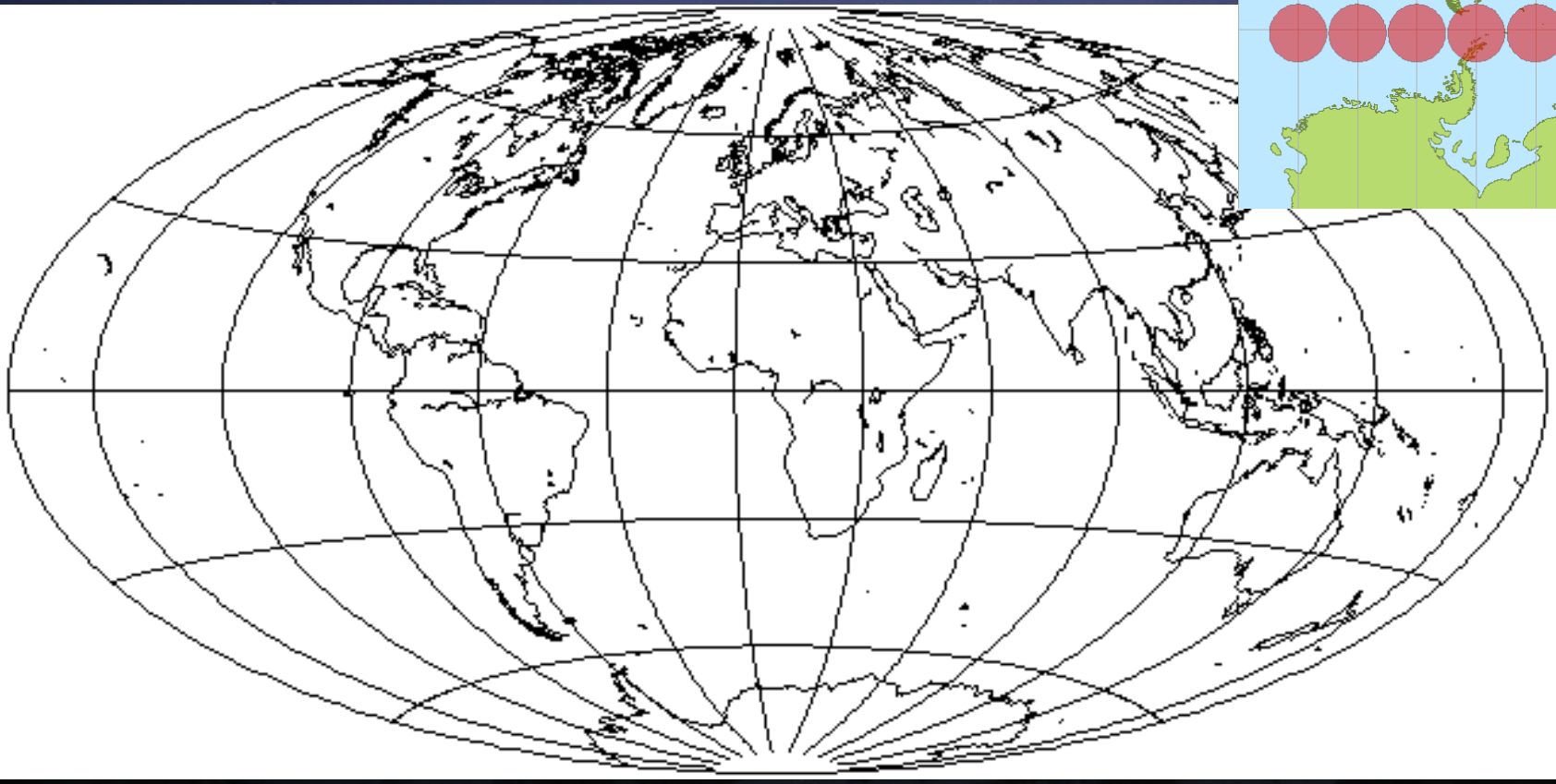
- 8 characters
- Galactic, celestial, ecliptic, helioecliptic, supergalactic.
- Aitoff
- Tan

Map Projections

- Aitoff Equal area.
  - Pixel area is kept constant over the entire sky.

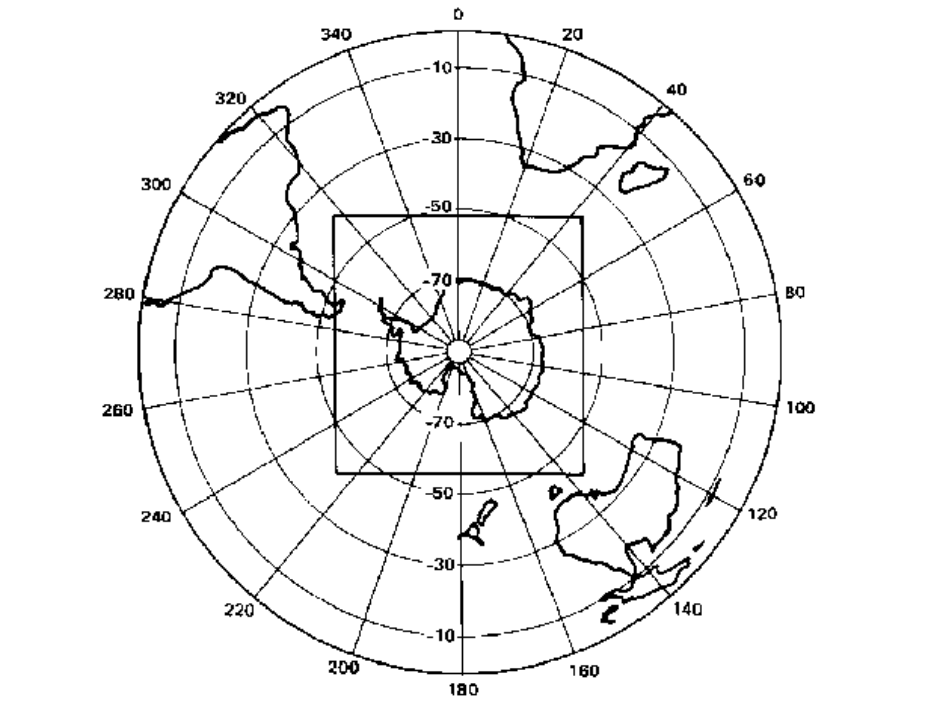
Stefan Kühn





Gnomonic Projection

- -TAN
- Great circles are straight lines centered on point.
- Distortion increases with distance from center.



Other Values

- CTYPE2 = 'GLAT-AIT' / COORDINATE TYPE
- TELESCOP= 'GALEX ' / GALEX s/c
- INSTRUME= 'GALEX ' / GALEX instrument
- FILTER = 'FUV ' / GALEX Band
- DATAMIN = 1. / Minimum valid data value
- DATAMAX = 11617.88 / Maximum data value
- DATE-OBS= '2003-06-07T05:02:29' / Start of first observation in mission
- EXPSTART= 52797.21006 / MJD start of first observation in mission
- EXPEND = 54980.24569 / MJD end of last observation in mission
- RESOLUTI= 0.1 / Spatial Resolution
- RESUNIT = 'Degrees ' / Spatial Resolution unit
- HLSPLEAD= 'Jayant Murthy' / Project lead
- PR_INV_L= 'Murthy ' / PI Last Name
- PR_INV_F= 'Jayant ' / PI First Name
- HLSPNAME= 'uv-bkgd ' / Name of HLSP project
- CITATION= 'Murthy 2014 ApJS 213, 32' / Citation
- HISTORY make_map_2 Version 1.0
- COMMENT Based on data at HLSP URL
- COMMENT http://www.iiap.res.in/personnel/murthy/Jayant_Murthy/Home.html
- END

Extensions

- Each has an independent header.
  - Defined name and number of bits specified.

- Header listing for HDU #2:
- XTENSION= 'IMAGE ' / IMAGE extension
- BITPIX = -32 / number of bits per data pixel
- NAXIS = 2 / number of data axes
- NAXIS1 = 3600 / length of data axis 1
- NAXIS2 = 1800 / length of data axis 2
- PCOUNT = 0 / required keyword; must = 0
- GCOUNT = 1 / required keyword; must = 1
- END

Programming finally

1. gdl

```
$ls
Q10901010031alif4ttagfcal.fit.gz
hlsp_uv-bkgd_galex_map_allsky_fuv_v1_skymap.fits.gz
$pwd
/Users/jayanth/user/education/course/data_analysis/data_files
$gdl

  GDL - GNU Data Language, Version 0.9.5

- For basic information type HELP,/INFO
- No startup file read (GDL_STARTUP/IDL_STARTUP env. var. not set).
- Please report bugs, feature or help requests and patches at:
  http://sourceforge.net/projects/gnudatalanguage/

GDL> im=mrdfits("hlsp_uv-bkgd_galex_map_allsky_fuv_v1_skymap.fits.gz",0,hdr)
% Compiled module: MRDFITS.
% Compiled module: FXPOSIT.
% Compiled module: MRD_HREAD.
% Compiled module: SXPAR.
% Compiled module: FXPAR.
% Compiled module: GETTOK.
% Compiled module: VALID_NUM.
MRDFITS: Image array (3600,1800)  Type=Real*4
% Compiled module: MRD_SKIP.
GDL>
```

1. gdl

```
GDL> hprint,hdr
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                  -32 / number of bits per data pixel
NAXIS   =                    2 / number of data axes
NAXIS1  =                 3600 / length of data axis 1
NAXIS2  =                 1800 / length of data axis 2
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
CRVAL1  =                   0. / REF POINT VALUE IN DEGREES
CRPIX1  =                1800. / REF POINT PIXEL LOCATION
CDELT1  =                 -0.1 / DEGREES PER PIXEL
CROTA1  =                   0. / ROTATION FROM ACTUAL AXIS
CTYPE1  = 'GLON-AIT'           / COORDINATE TYPE
CRVAL2  =                   0. / REF POINT VALUE IN DEGREES
CRPIX2  =                 900. / REF POINT PIXEL LOCATION
CDELT2  =                  0.1 / DEGREES PER PIXEL
CROTA2  =                   0. / ROTATION FROM ACTUAL AXIS
CTYPE2  = 'GLAT-AIT'           / COORDINATE TYPE
TELESCOP= 'GALEX   '           / GALEX s/c
INSTRUME= 'GALEX   '           / GALEX instrument
FILTER  = 'FUV     '           / GALEX Band
DATAMIN =                   1. / Minimum valid data value
DATAMAX =             11617.88 / Maximum data value
DATE-OBS= '2003-06-07T05:02:29' / Start of first observation in mission
```

Displaying FITS image

2. more

```
 im=mrdfits("data_files/hlsp_uv-bkgd_galex_map_allsky_fuv_v1_skymap.fits.gz",0,h
dr)
im(where(finite(im) eq 0))=0
window,xs=900,ys=450
rim=rebin(im,900,450)
tv,bytscl(rim,0,max(rim)/4)
plot,/nodata,/noerase,pos=[0,0,1,1],xstyle=5,ystyle=5,[0,3600],[0,1800]
oplot,[1800,1800],[0,1800],col=255

grid_gl = 180 - findgen(360)
grid_gl(n_elements(grid_gl)-2)=-179.999
grid_gb = findgen(6)*30-90
for i=0, n_elements(grid_gb)-1 do begin
 adxy,hdr,grid_gl,fltarr(n_elements(grid_gl))+grid_gb(i),x,y
 oplot,x,y,col=255
endfor

 grid_gb = findgen(180)-90
for i=-180,180,30 do begin
 adxy,hdr,fltarr(n_elements(grid_gb))+i,grid_gb,x,y
 oplot,x,y,col=255
endfor
 adxy,hdr,fltarr(n_elements(grid_gb))-179.99,grid_gb,x,y
 oplot,x,y,col=255
fits_plot.pro
```

2. bash

```
endfor

 grid_gb = findgen(180)-90
for i=-180,180,30 do begin
 adxy,hdr,fltarr(n_elements(grid_gb))+i,grid_gb,x,y
 oplot,x,y,col=255
endfor
 adxy,hdr,fltarr(n_elements(grid_gb))-179.99,grid_gb,x,y
 oplot,x,y,col=255
for i=-180,180,30 do begin
  adxy,hdr,i,0,x,y
  xyouts,x,y,strcompress(i)
endfor
for j=-90,90,30 do begin
 adxy,hdr,0,j,x,y
 xyouts,x,y,strcompress(j)
endfor

spica_gl=316.1123
spica_gb=50.8446
adxy,hdr,spica_gl,spica_gb,x,y
xyouts,x,y,'x',col=65535
xyouts,x+5,y,'Spica',col=65535
end
```

GDL 0