

Getting and Reading Data

Jayant Murthy

The Indian Institute of Astrophysics

www.iiap.res.in

jmurthy@yahoo.com



Data Sources

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

The screenshot displays the MAST website interface. At the top, the header reads "Barbara A. MIKULSKI ARCHIVE OF SPACE TELESCOPES". Below this is a navigation bar with links for "MAST", "STScI", "Tools", "Mission_Search", "Search Website", and "Follow Us". A secondary navigation bar includes "About MAST" and "Getting Started".

The main content area features a central announcement: "On Tuesday Sep. 9 between 8 and 9 PM (Eastern) there may be one or more interruptions to STScI's internet connection." Below this, a notice states: "As of April 13, the archive is now using the STScI Single Sign-On (SSO) identity manager. To check on your account click [here](#). For more information about how accounts were transitioned click [here](#)."

A paragraph describes the MAST project: "The Mikulski Archive for Space Telescopes (MAST) is a NASA funded project to support and provide to the astronomical community a variety of astronomical data archives, with the primary focus on scientifically related data sets in the optical, ultraviolet, and near-infrared parts of the spectrum. MAST is located at the Space Telescope Science Institute (STScI)."

A "News" sidebar on the right lists recent updates, including "September 03, 2015: Armstrong et al. light curves available for K2 Campaign 2" and "July 01, 2015: New HLSP: M83 Mosaics (W. Blair, JHU, 7 fields, 15 filters)".

A "Missions" sidebar on the right lists various space telescopes: Hubble, Hubble Legacy Archive, HSTonline, DSS, JWST, K2, KEPLER, SwiftUVOT, XMM-OM, BEFS (ORFEUS), Copernicus, and EPOCH.

A "Search Using the MAST Data Discovery Portal" section includes a list of features: "MAST Cross-Mission Search", "Integrated 3D All-Sky Viewer", "Access to Data from other Archives", and "User's Guide". Below this is a search input field labeled "Enter Target Name (or Coordinates):" and a "Search" button.

At the bottom, there is a Google search bar with a "WWW" radio button and a "MAST" radio button selected. A note at the very bottom states: "Note: STScI may provide links to Web pages that are not part of the STScI, AURA, NASA, or ESA domain. These sites are managed by organizations,"

Data Sources

- UV/Optical Data available from MAST

- <http://archive.stsci.edu>

- IR data from IPAC

- <http://ipac.caltech.edu>

The screenshot shows the IPAC website interface. At the top, there's a navigation bar with links for HOME, NEWS, EVENTS, GALLERY, MISSIONS, ARCHIVES, RESEARCH, and EDUCATION & PUBLIC OUTREACH. Below this is a sidebar menu with categories like 'About IPAC', 'Browse All Projects', 'IPAC's Legacy', 'Proposed Projects', 'Future Projects', 'In Development Projects', and 'Operational Projects'. The main content area features a 'FEATURED IMAGES' section with thumbnails for Spitzer, Herschel, and WISE. Below that is a 'HEADLINES' section with articles about the Herschel and Planck Space Systems Awards and the 12th anniversary of NASA's Spitzer. An 'EVENTS' section lists upcoming science talks, and a 'BULLETINS' section mentions an IPAC wide service outage.

Data Sources

- UV/Optical Data available from MAST.
 - <http://archive.stsci.edu>
- IR data from IPAC
 - <http://ipac.caltech.edu>
- Heasarc
 - <http://heasarc.gsfc.nasa.gov>

The screenshot shows the HEASARC website interface. At the top, there's a search bar and navigation links. Below that, a header identifies the National Aeronautics and Space Administration, Goddard Space Flight Center, Sciences and Exploration. A main navigation bar includes links for HEASARC Home, Observatories, Archive, Calibration, Software, Tools, and Students/Teachers/P. Below this, there's a section for 'NASA's HEASARC High Energy Astrophysics Science Archive Research Center'. A table lists various observatories and their corresponding NASA archives. To the right, there's a 'Picture of the Week' section featuring the HEASARC satellite and a 'Picture of the Day' from APOD showing the Earth from the Moon's surface. A 'Latest News' section on the far right contains several news items with dates and titles.

Guest Observer Facilities & Science Centers	
AGILE	ASCA
Astro-H	BeppoSAX
COBE	CGRO
Chandra	EUVE
Fermi	GALEX
HETE-2	INTEGRAL
MAXI	NICER
NuSTAR	ROSAT
RXTE	Suzaku
Swift	WMAP
XMM-Newton	
NASA Archives	
ADS	AstroGravS
EOSDIS	ExoArchive
HORIZONS	IRSA
KOA	LAMBDA
MAST	NExScI
NED	NSSDC

HEASARC Picture of the Week

APOD: Astronomy Picture of the Day

Latest News

- [XSPEC 12.9.0b.c.d Release](#) (01 Sep 2015)
Patch 12.9.0b fixes an issue with the The (b)vvapec model' patch 12.9.0c fixes a subtle problem defining linked parameters in models; and patch 12.9.0d fixes a problem in which the lmod command does not work if run from an xspec.rc file.
- [Reminder: Swift Cycle 12 proposals are due by Sept 25, 4:30PM EDT](#) (01 Sep 2015)
For details on the Swift Cycle 12 information program elements and how to submit proposals, see the link to the Swift Cycle 12 information page and also the [Cycle 12 M108 \(NGC 3556\) Chandra Discrete X-Ray Source Catalog](#) (31 Aug 2015)
This catalog listing the 0.3-7 keV properties of 83 discrete sources detected by Chandra in a 60 minute observation of the isolated edge-on spiral galaxy M 108 (from [Wang et al. 2003, ApJ, 598, 969](#)) is now available in Browse and Xamin.
- [Scientific mission of Suzaku declared complete](#) (28 Aug 2015)
JAXA has announced that it is abandoning its heroic effort to recover Suzaku, and declare the mission complete.

Xamin Quick Search [Xamin](#) [Browse](#)

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.

```
$!isthead 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
```

```
$!isthead 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

- 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

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
- CDELTA1 = -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
- CDELTA2 = 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.
- CDELTA1 and CDELTA2 are increments per pixel.
- CROTA1 and CROTA2 are rotation angles.
- CTYPE1, CTYPE2 are projections.

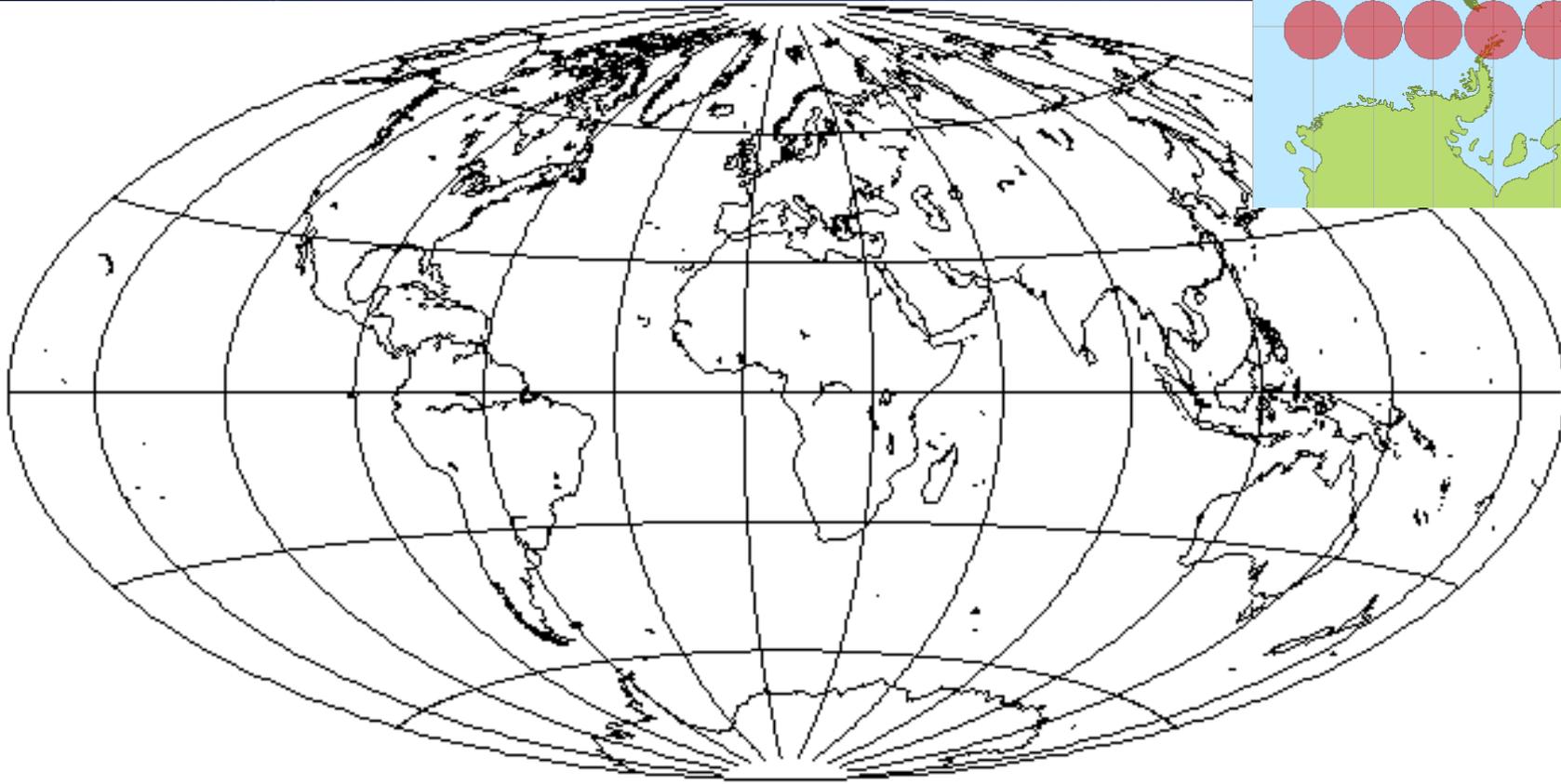
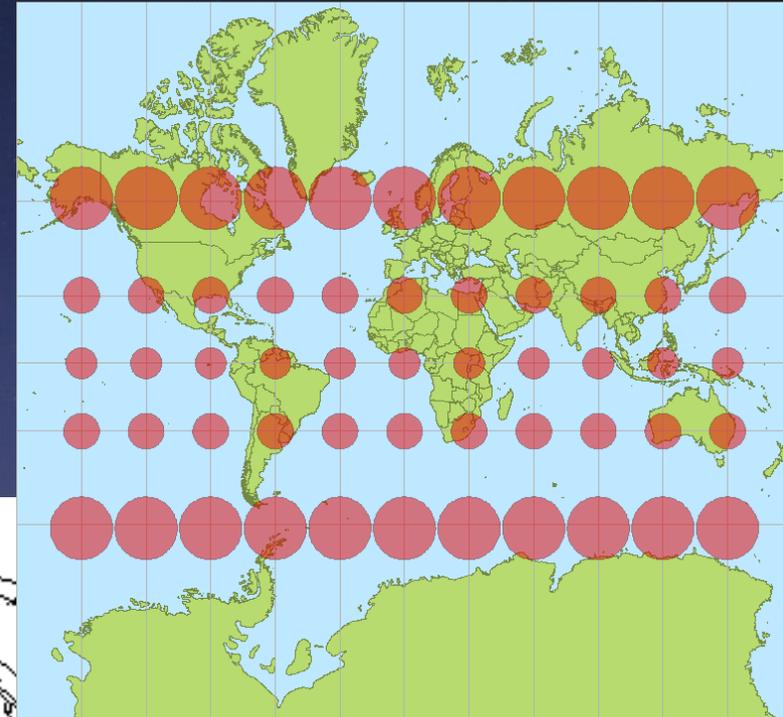
Projections

- GLON, GLAT
- RA--, DEC-
- ELON, ELAT, HLON, HLAT, SLON, SLAT
- -AIT
- -TAN
- 8 characters
- Galactic, celestial, ecliptic, helioecliptic, supergalactic.
- Aitoff
- Tan

Map Projections

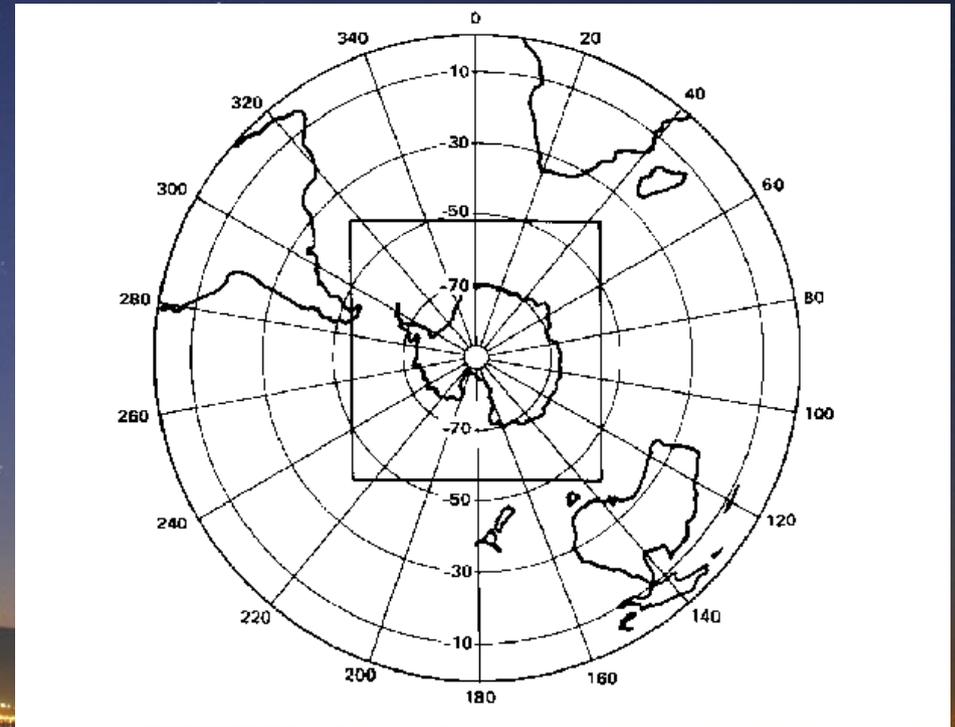
- Aitoff Equal area.
 - Pixel area is kept constant over the entire sky.

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: SXPAN.
% 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
CDELTA1 = -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
CDELTA2 = 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

```
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,bytsc1(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
```

