

TINA Demo 001: The TINA Astronomy Tool

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1 Introduction

The TINA astronomy tool provides functionality to read FITS (Flexible Image Transport System) format files into TINA. It is intended to act as a programming stub for more advanced astronomical image processing algorithms. The tool currently provides some basic image analysis functionality, and more advanced image analysis can be performed by using the astronomy tool to input images, and then passing them to other tools for further processing. The tool uses the CFITSIO library from NASA's High Energy Astrophysics Science Archive Research Center to handle FITS file input, the latest version of which is available from

`http://heasarc.gsfc.nasa.gov/docs/software/fitsio/fitsio.html`

Since the tool depends on this rather large external library, it is not included in the main TINA distribution, but can be downloaded from the projects area of the CVS repository, or as a TINA Demo.

The functionality available from the TINA astronomy tool has been modelled on that available in the Fits Viewer programme, which is available from

`http://heasarc.gsfc.nasa.gov/docs/software/fertools/fv/`

2 Installation

In order to use the TINA astronomy tool, you must already have compiled and installed the TINA libraries. See the TINA website

`http://www.tina-vision.net`

for instructions.

The TINA astronomy tool project can be obtained either from the demos page of the TINA website or from the TINA CVS repository using the commands

```
cvs -d :pserver:anonymous@cvs.tina-vision.net:/home/tina/cvs login
(press enter when prompted for a password)
cvs -d :pserver:anonymous@cvs.tina-vision.net:/home/tina/cvs co tina-projects/astro_tool
```

This should check out the following files to the current directory

```
Makefile: project Makefile.
astro_test.cls: macro for running the tinaTool.
cfitsio2510.tar.gz: the cfitsio library.
fits_standard.pdf: a document describing the FITS format.
test_images: a directory containing some example FITS images
tinaTool.c: source file for the top-level tinaTool.
tlastroCore_tool.c: source file for the Astronomy tool.
tlastroCore_tool.h: header file for the Astronomy tool.
tlastroCore_view.c: source file for the Astronomy tool Tv functions.
tlastroCore_view.h: header file for the Astronomy tool Tv functions.
001_astronomy_tool.pdf: this document.
```

To build the Astronomy tool, first unzip, untar and build the CFITSIO library using

```
gunzip cfitsio2510.tar.gz
tar -xvf cfitsio2510.tar
cd cfitsio
./configure
make
```

Note that more recent versions of the CFITSIO library may be available: these can be downloaded from the website listed above and used in place of the reference version distributed with the Astronomy tool.

Second, build the tinaTool. The Makefile distributed with the project may require some manual editing: it assumes that you installed the TINA libraries in the /usr/local/Tina5 directory, and that you are using the Xview widget set. Open the Makefile in an editor, set the TINA-X-GUI variable to specify the widget set you wish to use, and edit any paths that do not apply for your system. Finally, type “make” to build the tinaTool executable.

To run the Astronomy tool, type

```
./tinaTool -f astro_test
```

3 Usage

3.1 Graphics

The TINA Astronomy tool provides a single graphics stream (a Tv) for image display. Click on “New Tvtool” in the top level tinaTool window to start a new Tvtool to display this graphics stream. Then click on “Astro” in the Tv list of the Astronomy tool, and finally “install” in the Tvtool window. The Tvtool will now display any images loaded into the Astronomy tool. The astro-test macro will perform this step for you.

3.2 Image Input

In order to use the Astronomy tool, some knowledge of the FITS format is required. The FITS format is very flexible, and can contain a range of both image and numerical data. In general, a FITS file should contain one or more header data units (HDUs) consisting of a header describing the data, and the data itself. The first HDU must contain an image, but further HDUs can contain either images or tables of data.

The TINA Astronomy tool supports a subset of FITS data types for input. In order to load an image, first enter the directory and file names of the FITS file into the relevant fields. The test-images directory of the project contains some example FITS files, and the astro-test macro sets up the tool for loading one of them: an image of the sky around the X-ray source Cygnus X1 (which is believed to contain a black hole). In order to check the number of HDUs contained in the specified FITS file, click the “Query FITS” button. The number and type of each HDU in the file will be displayed in the text window of the top-level tinaTool. By default the input functions will load the image from the first HDU. If an image from a later HDU is required, specify its number in square brackets after the filename e.g. filename.fits[2].

In order to display the header information from the specified HDU of a FITS file, click the “Read header” button. The entire header will be displayed in the text window of the top-level tinaTool. Take particular note of the NAXIS keywords: these specify the dimensionality of the data. NAXIS specifies the number of dimensions in the data array, and NAXIS1, NAXIS2 etc. specify the length of each axis. Note that if any of the NAXISx keywords have values of unity, then the dimensionality of the data is lower than it appears to be e.g. if NAXIS=4, NAXIS1=512, NAXIS2=512, NAXIS3=1, and NAXIS4=1, the data is a 2D image contained in a 4D array: it should be read in using the 2D image input function.

The Astronomy tool supports input of 1D, 2D and 3D data. Three buttons are provided for loading images, depending on the dimensionality of the image contained in the specified HDU of the FITS file. “Input 2D FITS” will input a 2D image, and display it in the Astronomy Tv. “Input 3D FITS Seq” will input an entire 3D volume and display it in the Sequence tool. “Input 3D FITS Frame” will input a single 2D image from a 3D volume, and display it in the Astronomy Tv. The frame number is specified in the “Frame no.” field: check the header to find the number of frames in the volume, and note that allowable frame numbers start at one rather than zero.

3.3 Basic Image Analysis

The Astronomy tool provides two types of basic image analysis. First, it can display the coordinates and grey-level value of a given pixel in either image coordinates (x, y) or WCS (World System Coordinates: RA and DEC). To use this functionality, right-click on the “Mouse” menu of the Astronomy tool. Several choices are available: “NULL” resets the mouse to no functionality, “grey” sets the coordinate system to image coordinates, “WCS” sets the coordinate system to RA and DEC, and “both” will provide both coordinate systems simultaneously. Then left-click the mouse whilst the pointer is over the Astronomy Tv to display the coordinates and grey-level of the pixel under the pointer. All results are displayed in the text window of the top-level tinaTool.

Note that the WCS co-ordinate system calculations are currently performed using the functions provided by the CFITSIO library. These functions have now been deprecated, and do not handle the most recent versions of the FITS format definition. If you require accurate WCS definitions, refer to the NASA High Energy Astrophysics Science Archive Research Center webpage (URL above) for external libraries capable of providing this functionality.

Second, the Astronomy tool can calculate the total flux (for the units, refer to the header of the HUD) within a given region of an image. Specify a region by right-clicking on the “ROI” menu of the Astronomy Tv, and select either “rect” or “poly” (rectangular or polygonal regions). If “rect” is selected, you can draw a rectangular region in the Astronomy Tv by left-clicking and dragging the mouse. If “poly” is selected, specify a starting point for the region by right-clicking in the Astronomy Tv. Specify further points by left-clicking, and finalise (join the final point to the first to completely enclose a region) by clicking the center button. Once a region has been specified, click on the “Total flux” button to count the number of pixels in the region and to sum their values. All results are displayed in the text window of the top-level tinaTool.

3.4 Advanced Image Analysis

More advanced image analysis functionality can be accessed using other Tina tools. First, click “Push” to copy the image currently loaded into the Astronomy tool to the stack of the Imcalc tool. It can be processed here using the basic mathematical functionality available in the Imcalc tool, or popped from here into other tools: e.g. the Colour tool for false colour image production. See the TINA User’s Guide for further information.

4 Quick Reference

- TV button: sets the astronomy tool Tv as the current Tv, for installation onto a Tv Tool.
- Mouse menu: sets the function performed when the left mouse button is clicked whilst the pointer is over the astronomy tool Tv. Available choices are: NULL (no function); grey (display the grey level and position of the pixel under the mouse pointer in image coordinates); WCS (display the grey-level and position of the pixel under the mouse pointer in World System Coordinates i.e. right-ascension and declination); and both (display the position in both image and WCS coordinates and the grey level of the pixel under the mouse pointer).
- Directory and file fields: specifies the directory and file names of the FITS file to be read.
- Query FITS button: displays the number of header data units (HDUs) in the specified FITS file.
- Read header button: displays the header information for the current HDU.
- Input 2D FITS button: inputs a 2D image from a FITS file, for display in the Astronomy Tool Tv.
- Input 3D FITS- ζ Seq button: inputs an entire 3D image volume from a FITS file into the TINA sequence tool, for display in the Sequence tool Tv.
- Input 3D FITS Frame button and Frame no. field: input a single frame, the number of which is specified in the frame no. field, from a FITS file containing a 3D image volume into the astronomy tool. Allowable frame numbers start at 1 rather than 0. The total number of frames contained in a FITS file can be determined using the “Read header” button.
- Push button: copies the current image from the astronomy tool (as displayed in the astronomy tool Tv) to the Imcalc tool (for display in the Imcalc tool Tv).
- Pop button: replaces the current image in the astronomy tool (as displayed in the astronomy tool Tv) with the image from the top of the Imcalc stack (as displayed in the Imcalc Tv).

- Total Flux button: sums the total pixel values within the image or a specified region, which can be defined using the ROI menu of the astronomy tool TV.

5 Image Gallery

Figure 1 shows a false colour image of the galaxy NGC 1316 (a second galaxy, NGC 1317, can be seen above the main object) generated using TINA from the optical (shown in red) and radio (shown in cyan) FITS files `ngc1316o.fit` and `ngc1316r.fit` images in the `test-images` directory. This object is the brightest radio source in the Fornax galaxy cluster, and is located at rather over 100 million light years from Earth. The coincidence of the radio source (known as Fornax A) with NGC 1316 demonstrates that they are the same object. The lobes seen in the radio image are believed to be the result of a galactic merger.

In order to generate this image, the two source files were read in using the TINA astronomy tool, and pushed to the Imcalc stack. The optical image was scaled to a dynamic range of 0 to 255, and used as the red field of the colour image. The radio image was square-rooted and slightly blurred using a small Gaussian kernel to highlight the detail in the lobes, scaled to a dynamic range of 0 to 255 and used as the blue and green fields of the image. Finally, the image was output as ppm from the Colour tool, and converted to postscript for inclusion in this document.

The following sequence of button presses regenerates this image:

- Run TINA using the command

```
./tinaTool -f astro_test
```

- The filename for the optical image has already been entered into the Astronomy Tool. Press “Input 2D FITS” in the Astronomy Tool to input the image, which appears in the Astronomy Tvtool.
- Press “push” in the Astronomy Tool to push the image onto the Imcalc stack, TINAs internal stack memory, where it can be manipulated using the basic image processing functions available in the Imcalc Tool or transferred to other tools. The image appears in the Imcalc Tvtool, which always displays whatever image is on the top of the stack.
- Press “scale” in the Imcalc Tool. This scales the dynamic range of the image to lie between 0 and the value given in the “scale” field of the Imcalc Parameters dialog box, which you can access by clicking “Imcalc Params” in the Imcalc Tool.
- Press “R Pop” in the Colour Tool to transfer the image from the top of the stack into the Red Tv of the Colour Tool. The image will disappear from the Imcalc Tvtool and appear in the Red Tvtool.
- Change the filename in the Astronomy tool to “`ngc1316r.fit`”, and press “Input 2D FITS” in the Astronomy Tool. This will input the radio image, which will again be displayed in the Astronomy Tvtool. Press “push” in the Astronomy tool to push this image onto the Imcalc stack. As before, it will appear in the Imcalc Tvtool.
- In order to highlight the detail in the radio lobes, square-root the image by pressing “sqrt” in the Imcalc Tool, and then press “gauss” to apply a little Gaussian blurring. The kernel size of the Gaussian (in pixels) is set by the “sigma” field of the Imcalc Parameters dialog box, and the “range” field sets the point at which the kernel will be truncated: this should always be around five times the kernel size in order to preserve accuracy. Finally, press “scale” in the Imcalc Tool to scale the dynamic range of the image.
- Aside: you can follow these image manipulations using the histogram function. If you wish to do this, after you have pushed the image to the Imcalc stack, start a new Tvtool using the “New Tvtool” button in the top level tinatool, drag it to a convenient location on the screen, then press “graph” in the Tv choice list of the Imcalc tool and press “install” in the newly created Tvtool. This installs the Tvtool onto the graph graphics stream of the Imcalc tool, so that it will display any graphics sent to that stream. Then, press “hist” in the Imcalc Mice list of the Imcalc tool, move the mouse pointer to somewhere within the image displayed on the Imcalc Tvtool, and click and drag with the left mouse button to draw a rectangular region within the image. The imcalc graph Tvtool will display the intensity histogram of the pixels within the rectangular region.
- We need two copies of the radio image to act as both the green and blue fields of the colour image, so press “dup” in the Imcalc Tool to duplicate the image. The copy is placed onto the stack (i.e. there are now identical image both on the top of the stack and second on the stack). The second-on-stack image can be viewed by installing a Tvtool onto the Imcalc2 graphics stream if desired.



Figure 1: False colour image of NGC1316 (optical in red, radio in cyan), generated using the TINA Astronomy, Imcalc and Colour tools.

- Press “G Pop” and then “B Pop” to transfer the radio images to the green and blue Tvs of the Colour Tool.
- Enter a directory name and filename for image output into the “Directory” and “File” fields of the Colour Tool. The “Directory” field will accept either relative or absolute pathnames. The filename should have the proper extension i.e. .ppm, since this will not be added by TINA, and you should be aware that you will not be warned about overwriting existing files.
- Finally, press ”Output PPM” in the Colour Tool to output a colour image in PPM format using the red, green and blue fields displayed in the Colour Tool Tvs. The image can then be converted to other formats using the Linux “convert” command or viewed in an image viewer.