

# **LINUX ASTRONOMICAL SOFTWARE**

**Georgi Petrov**

*Institute of astronomy and NAO*

**VIII SERBIAN-BULGARIAN  
ASTRONOMICAL CONFERENCE**

**08-12 MAY, 2012, LESKOVAC, SERBIA**

1. **Data Analysis Packages**
2. **GRID software** - details presented during the VII\_SBAC
3. **Modeling and Simulations**
4. **Organizers**
5. **Planetariums software**
6. **Radio & Interferometry software**
7. **Spectrum Analysis**
8. **Visualization**
9. **VO software** — details presented during the VII\_SBAC
10. **X\_ray analysis software**

## ***1. Data Analysis Packages***

**1.1 CCDPROC** - basic reductions on raw CCD images

**1.2 FIGARO** - a data reduction system

**1.3 IDL** - Data Analysis/Visualization package.

**1.4 IRAF** - an Image Reduction and Analysis Facility

**1.5 ISIS** - a complete package to process CCD images

**1.6 MIDAS** - ESO Munich Image Data Analysis System

**1.7 SEXTRACTOR** - a program that **builds a catalog of objects**

**1.8 STARFINDER.IDL** - a code for deep analysis of stellar fields

**1.9 STARLINK** - a full set of data reduction and analysis tools.

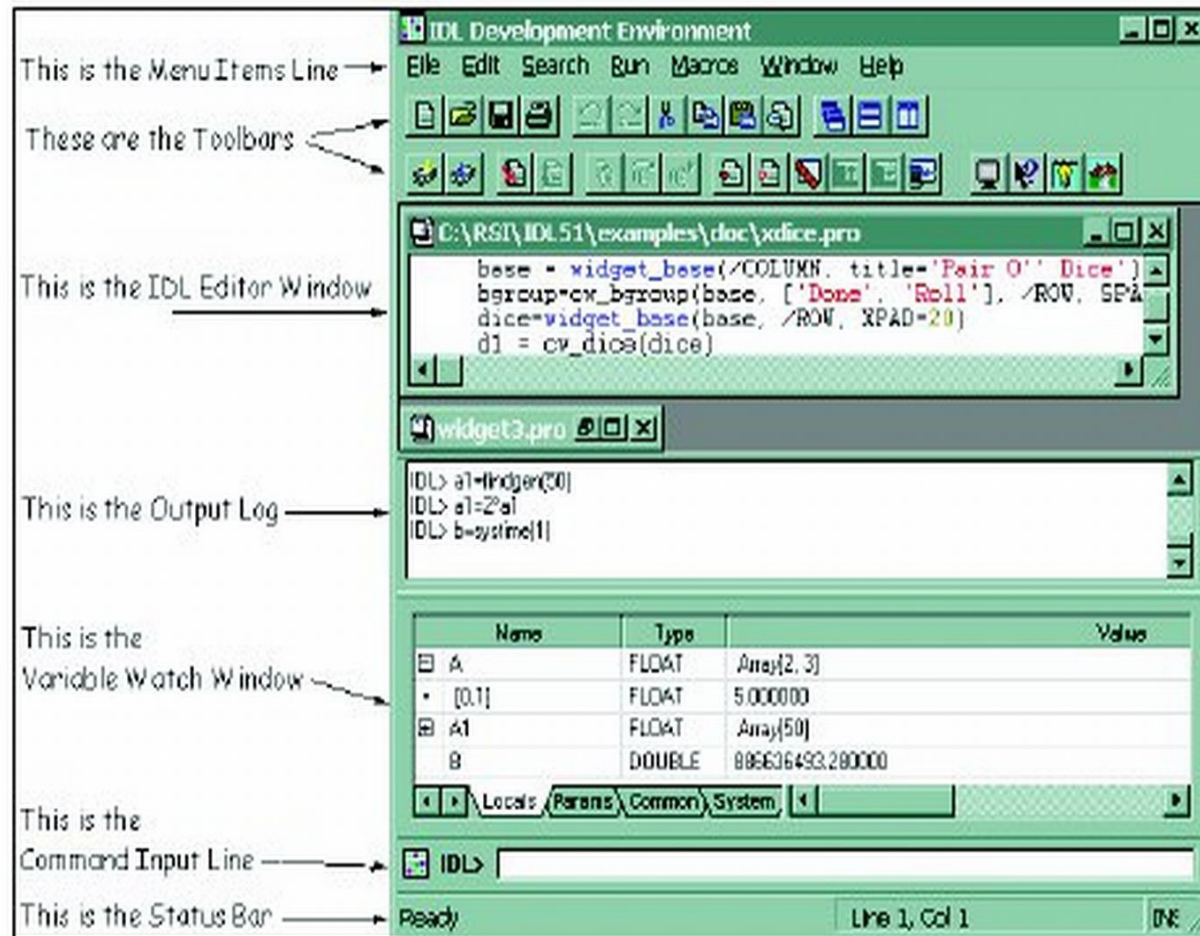
**1.10 STSDAS** - a software package for reducing and analyzing astronomical data.

**1.11 VISTA** - an image processing program

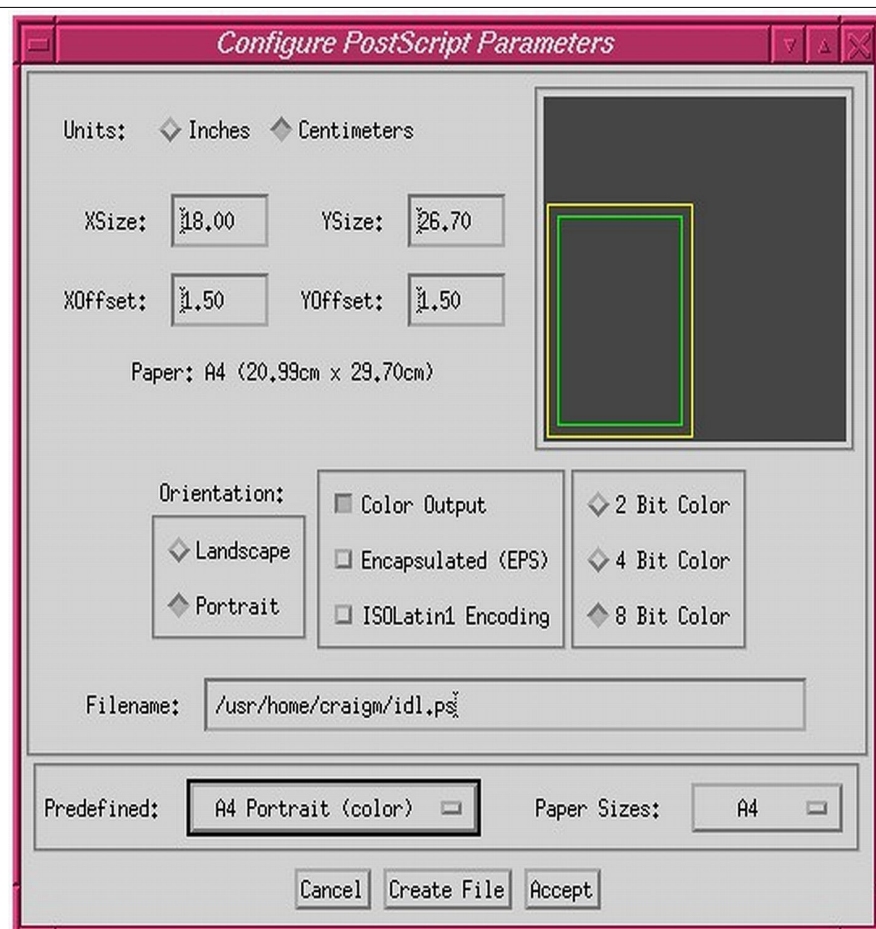
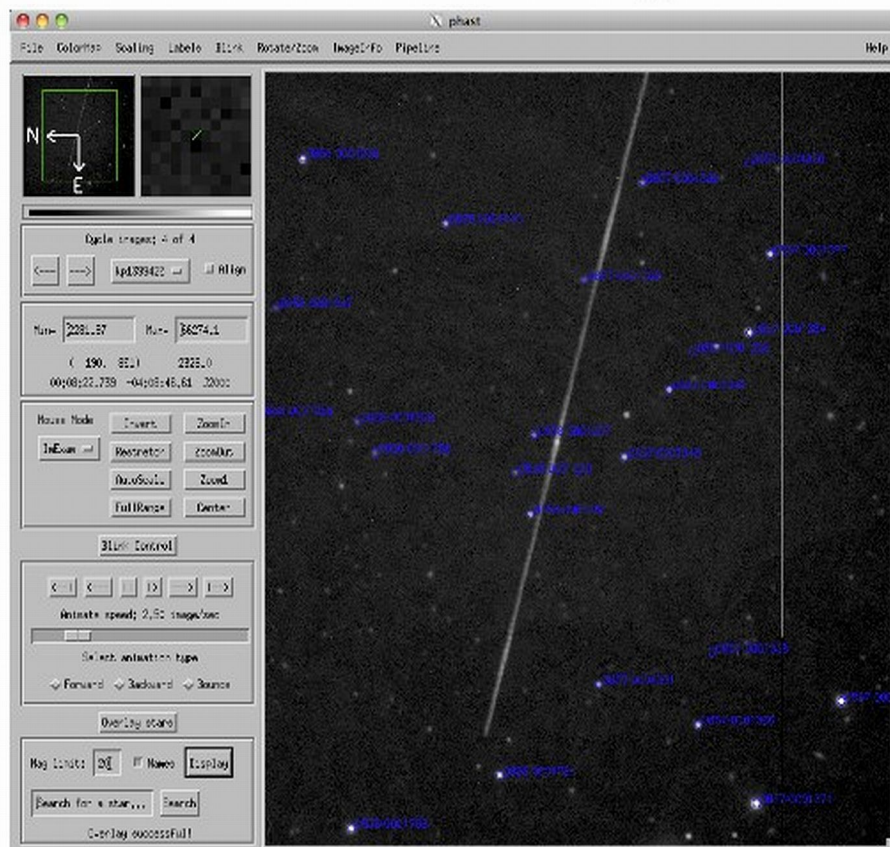
**1.1 CCDPROC** - *performs basic reductions on raw CCD images* (overscan bias subtraction, trim, zero and/or dark subtraction, and flat fielding), creating a reduced image ready for subsequent analysis. A process control (proc) file contains the instructions for performing the reduction. **Ccdproc** is designed to be used *for fast pipeline reductions of CCD images*, but requires that the necessary zero (2D Bias) and normalized flat-field images be already prepared using standard image reduction packages like IRAF, VISTA, IDL, etc.

**1.2 FIGARO** - a data reduction system that originated at **Caltech** at the Anglo-Australian Observatory. Although it is intended to be able to deal with any sort of data, almost all its applications to date are geared towards *processing optical and infra-red data*.

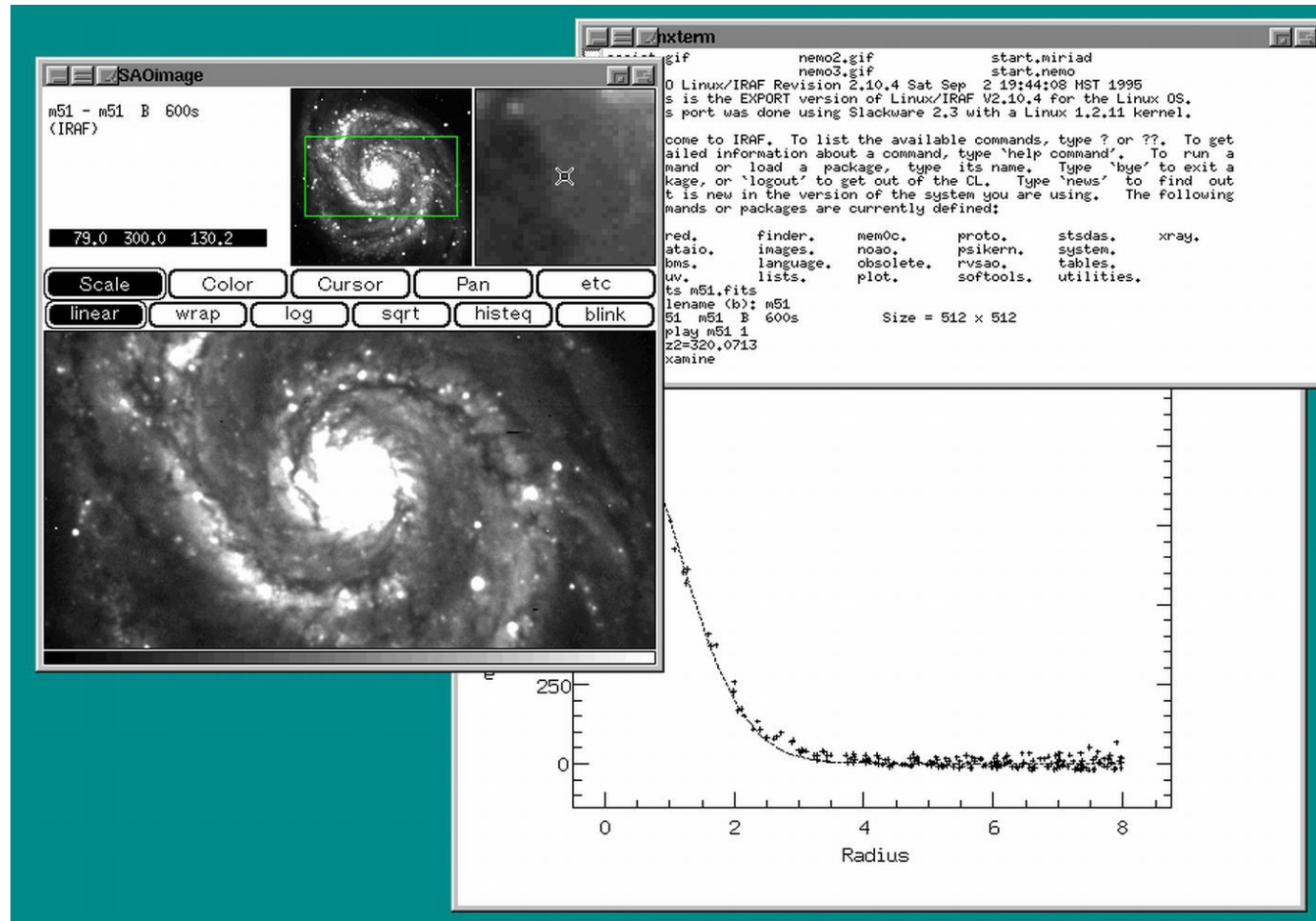
**1.3 IDL - *DataAnalysis/Visualisation package*.** The **IDL Astronomy Users Library** is a central repository for **low-level astronomy software** written in the commercial language **IDL**. The Library is a collection of procedures from which users can pick and choose for their own use.



# PhAst: A flexible IDL image tool



1.4 IRAF - IRAF is the *Image Reduction and Analysis Facility*, a general purpose software system for the reduction and analysis of astronomical data.



1.5 ISIS - ISIS is *a complete package to process CCD images using the image Optimal subtraction method* (Alard & Lupton 1998, Alard 1999). ISIS includes a number of facilities to *compute the light curves of variables objects from the subtracted images*.

# ISIS

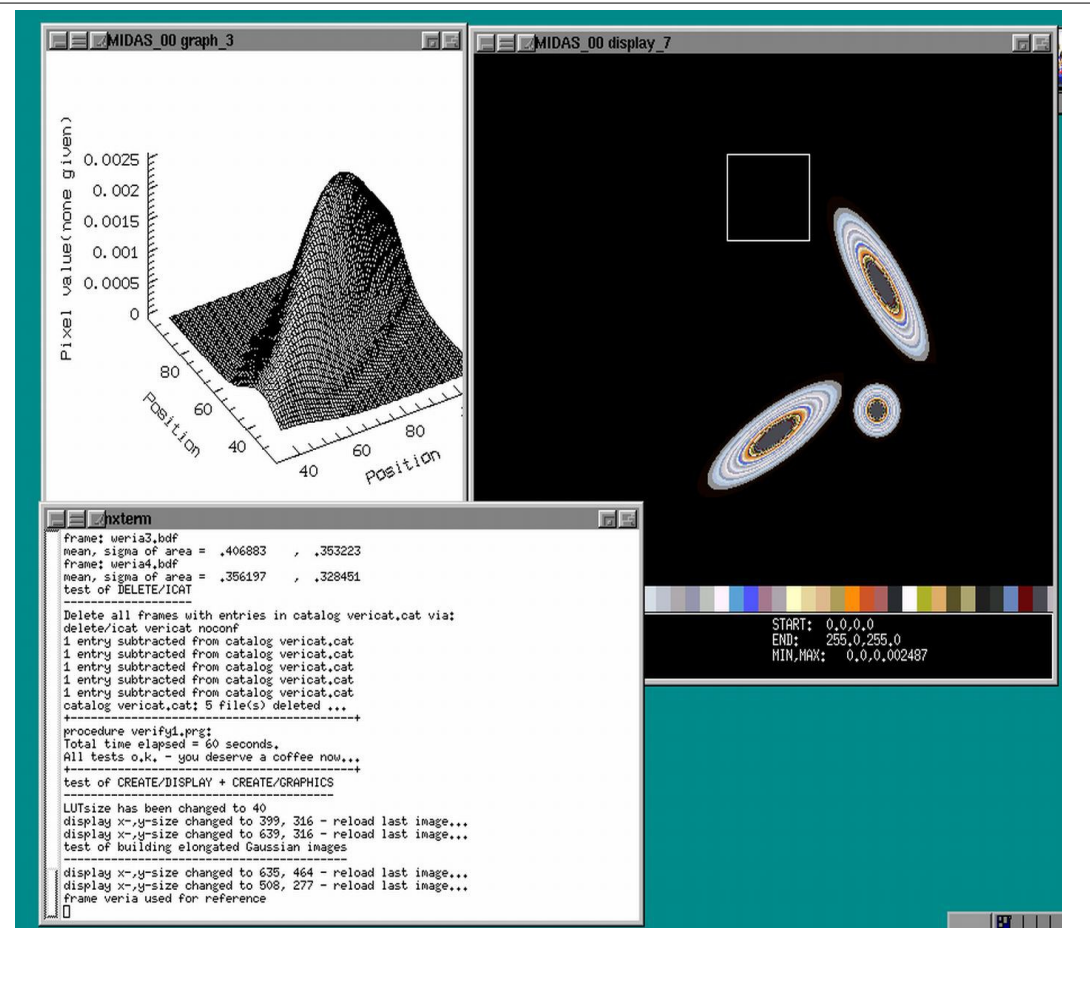


## IMAGE SUBTRACTION PACKAGE

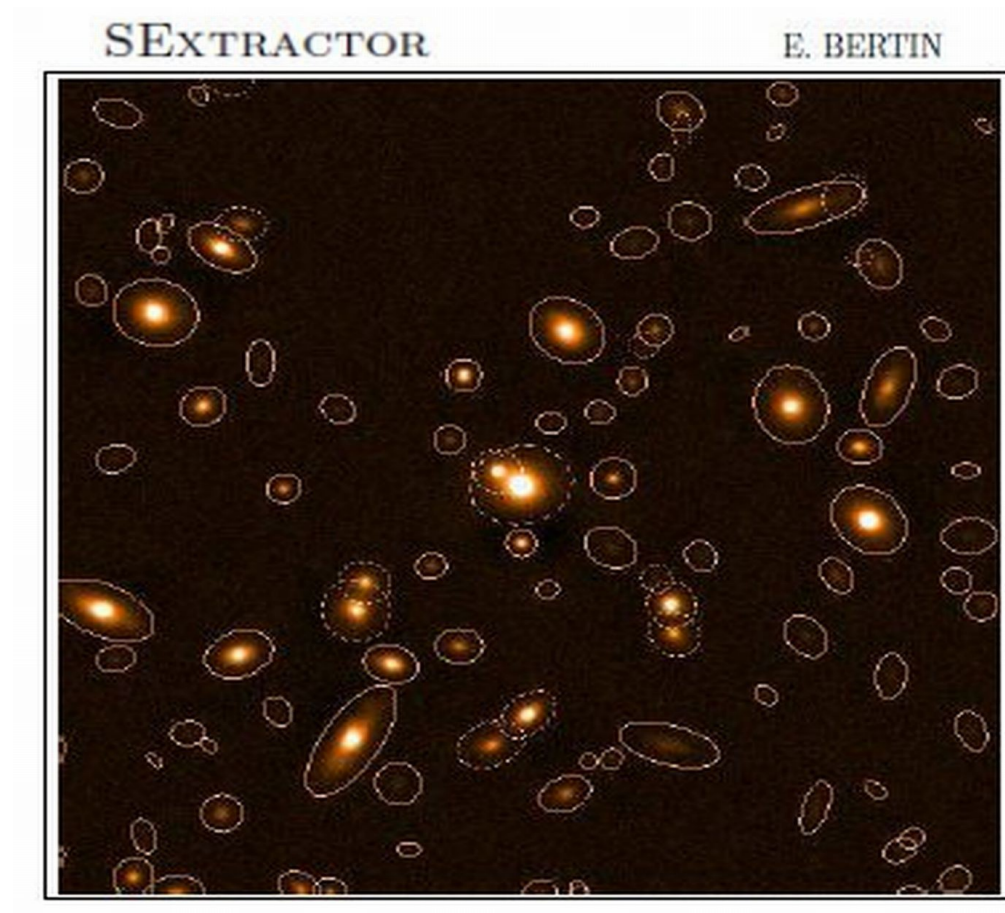


## 1.6 MIDAS - the acronym for the Munich Image Data Analysis System which is developed and maintained by the European Southern Observatory.

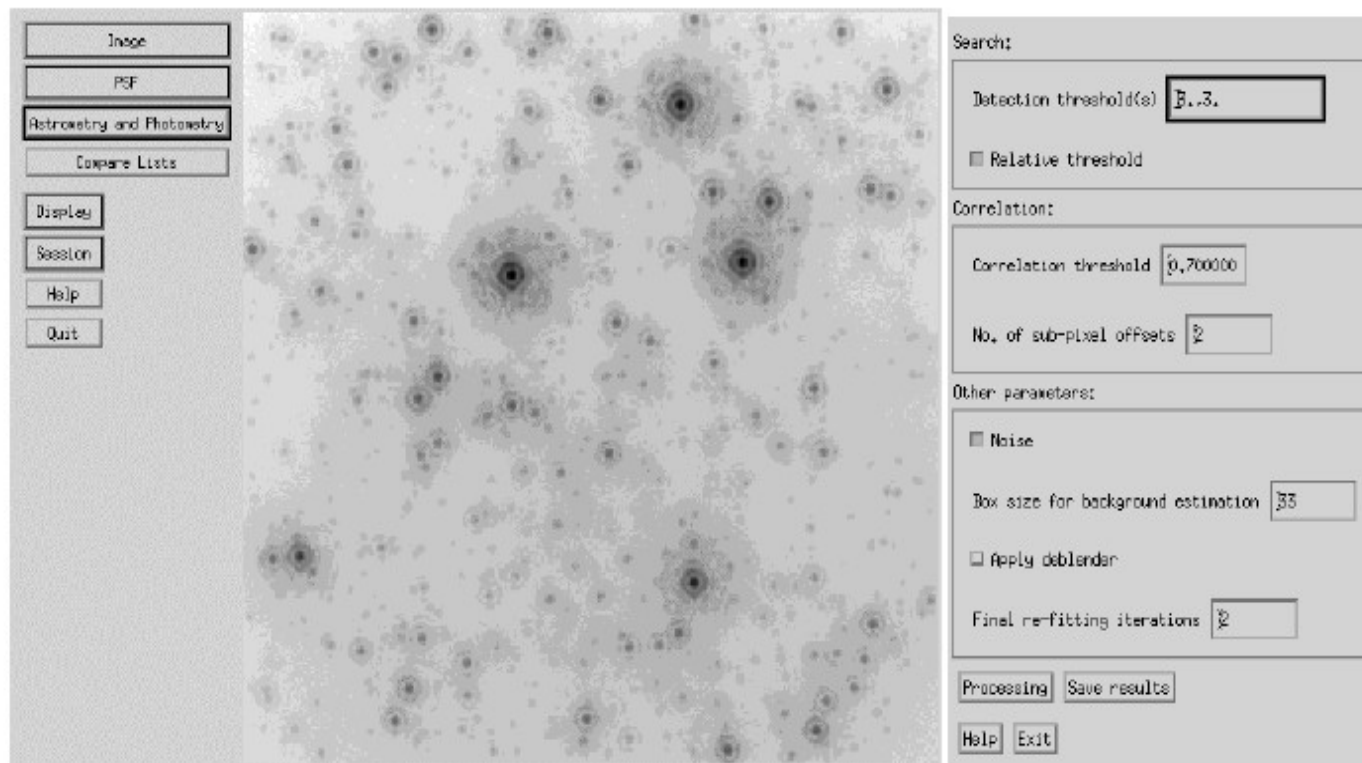
The official name, *ESO-MIDAS*, is a registered trademark. The ESO-MIDAS system provides **general tools for image processing and data reduction** with emphasis on astronomical applications including imaging and special reduction packages for ESO instrumentation at La Silla. In addition *it contains applications packages for stellar and surface photometry, image sharpening and decomposition, statistics and various others.*



**1.7 SEXTRACTOR** - a program that **builds a catalog of objects** *from an astronomical image*. Although it is particularly oriented towards reduction of large scale galaxy-survey data, it can perform reasonably well on moderately crowded star fields. A "teaching" program for object selection is **EYE**.



**1.8 STARFINDER.IDL** - an *code for the deep analysis of stellar fields*, designed for Adaptive Optics well-sampled images. The *Point Spread Function is extracted directly from the frame*, to take into account the actual structure of the instrumental response and the atmospheric effects. The code is written in IDL language and organized in the form of a self-contained widget-based application, provided with a series of tools for data visualization and analysis.



**1.9 STARLINK** - A full set of data reduction and analysis tools. The Starlink Project was a long running UK Project supporting astronomical data processing. It was shut down in 2005 but **the software continues to be developed at the [Joint Astronomy Centre](#) and is open source.**



**1.10 STSDAS** - The Space Telescope Science Data Analysis System (**STSDAS**) is a software package for reducing and analyzing astronomical data. It is layered on top of [IRAF](#) and provides general-purpose tools for astronomical data analysis as well as routines specifically designed for HST data. The [TABLES](#) package sits alongside STSDAS and provides tools and libraries for working with tabular data. STSDAS requires TABLES, but one may use TABLES without STSDAS.

**1.11 VISTA** - There are two different versions, distributed as *xvista*:

- **Xvista version 7.xx** maintained and distributed by **Jon Holtzman** at the New Mexico State University, is an image processing program designed to be used primarily with astronomical data. It contains routines *for reading, displaying, basic image processing, and specialized tasks for the analysis of astronomical imaging and spectroscopic data.*
- **Richmond & Treffers XVista, (ver. 0.1.9/2010)** is a suite of programs *for analyzing and displaying astronomical images* on computers running Unix-like operating systems and X Windows.

## **2. GRID SOFTWARE** - details presented during the VII\_SBAC

- 2.1. **AMEEPAR** - parallel processing for hyperspectral imaging
- 2.2. **GADGET-2** – a freely available code for cosmological N-body/SPH simulations
- 2.3. **CRBLASTER** : a fast parallel-processing program for cosmic ray rejection
- 2.4. **N\_body-sh1p** - a parallel direct N\_body code - an Educational N-body integrator
- 2.5. **VirGO**
- 2.6. **SkyMaker** - a program that simulates astronomical images.
- 2.7. **Cosmic simulation** -
- 2.8. **A virtual universe** – GIMIC and Millennium simulations
- 2.9. **Nbody6++** - direct N-body integrators used for simulations of dense star clusters, galactic nuclei, and problems of star formation.
- 2.10. **Clusterfinder**
- 2.11. **Cactus** - toolkit to numerically simulate extremely massive bodies, such as neutron stars and black holes.
- 2.12. **SETI@home** - SETI (Search for Extraterrestrial Intelligence) - to detect intelligent life
- 2.13 **Einstein@home**
- 2.14. **Milkyway@home**
- 2.15. **SyntSpec** - The Synthetic spectra modeling under GRIDCOM interface.

### ***3. Modelling & Simulations***

**3.1 CLOUDY.IDL** - simulate emission line region spectrum or structure.

**3.2 COSMICS** - a package of programs for cosmological models

**3.3 FASTELL** - a code to calculate the lensing deflection and magnification matrix

**3.4 GADGET** - a code for cosmological N-body/SPH simulations

**3.5 GALACTICUS** - builds a comprehensive model of galaxy formation

**3.6 GALFIT** - a two-dimensional (2-D) fitting algorithm designed to extract structural components from galaxy images

**3.7 N-BODY simulations** - a parallel direct N-body code

**3.8 NIGHTFALL** - produces animated views of eclipsing binary systems

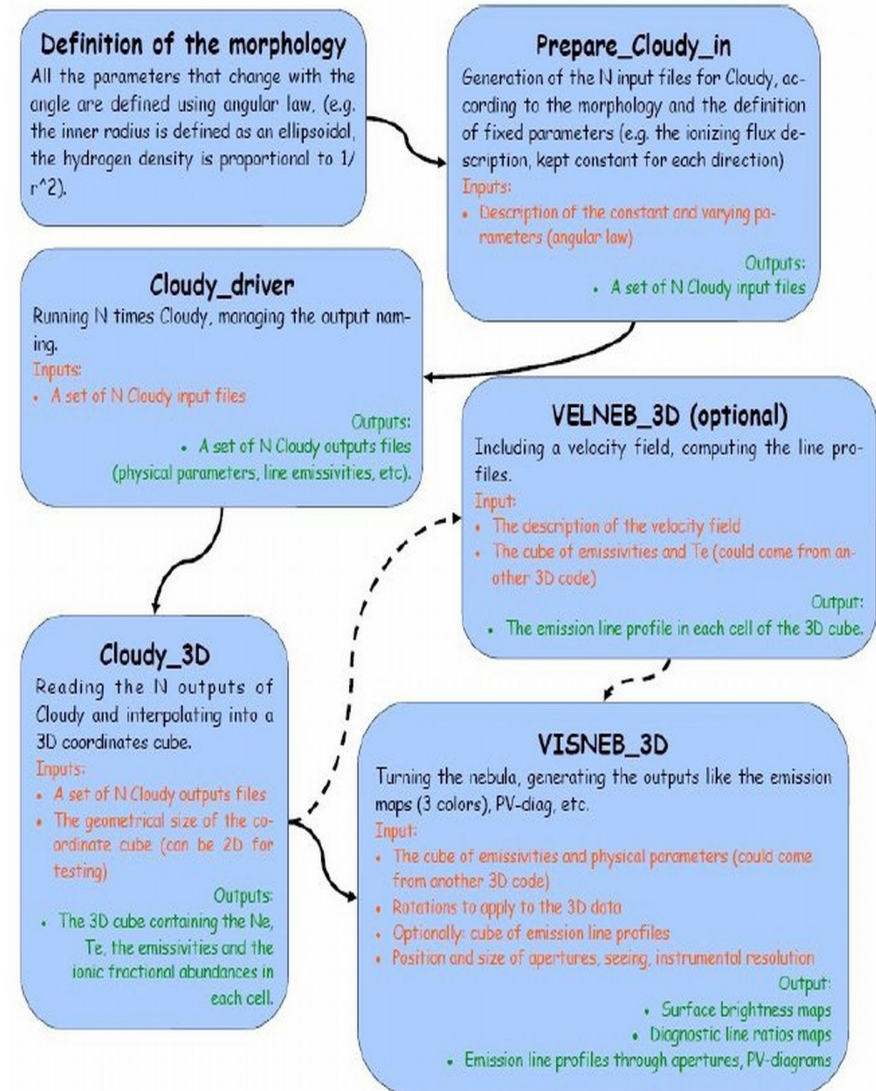
**3.9 PANDORA** - calculates non-LTE stellar atmosphere models

**3.10 SYNSPEC** - a general spectrum synthesis program

**3.11 TIPSY** - displays and analyze the results of N-body simulations

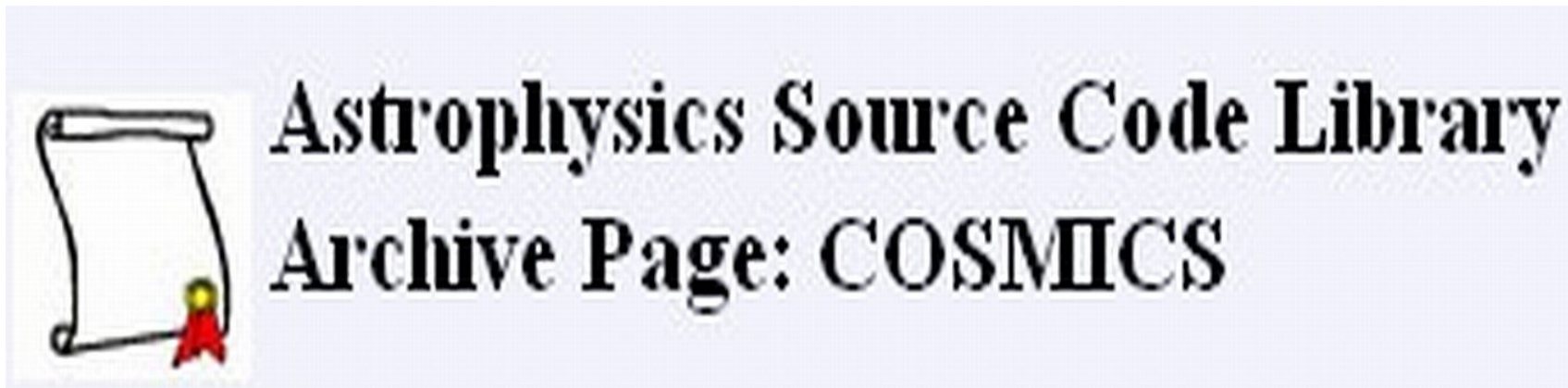
**3.12 TLUSTY** - accomplishes a wide range of spectroscopic diagnostics.

**3.1 CLOUDY.IDL** - designed to **simulate emission line regions ranging from the intergalactic medium to the Broad Line Regions of Quasars**. Many environments are encountered in which dilute gas is heated and ionized by the radiation field of a central object. Under these circumstances **it is possible to predict the physical conditions** (e.g. the run of ionization, density, and temperature) **of the gas, and its resulting emission-line spectrum**, in a unique and self-consistent manner. For this the equations of statistical and thermal equilibrium, equations which balance ionization-neutralization processes, and heating-cooling processes are used.





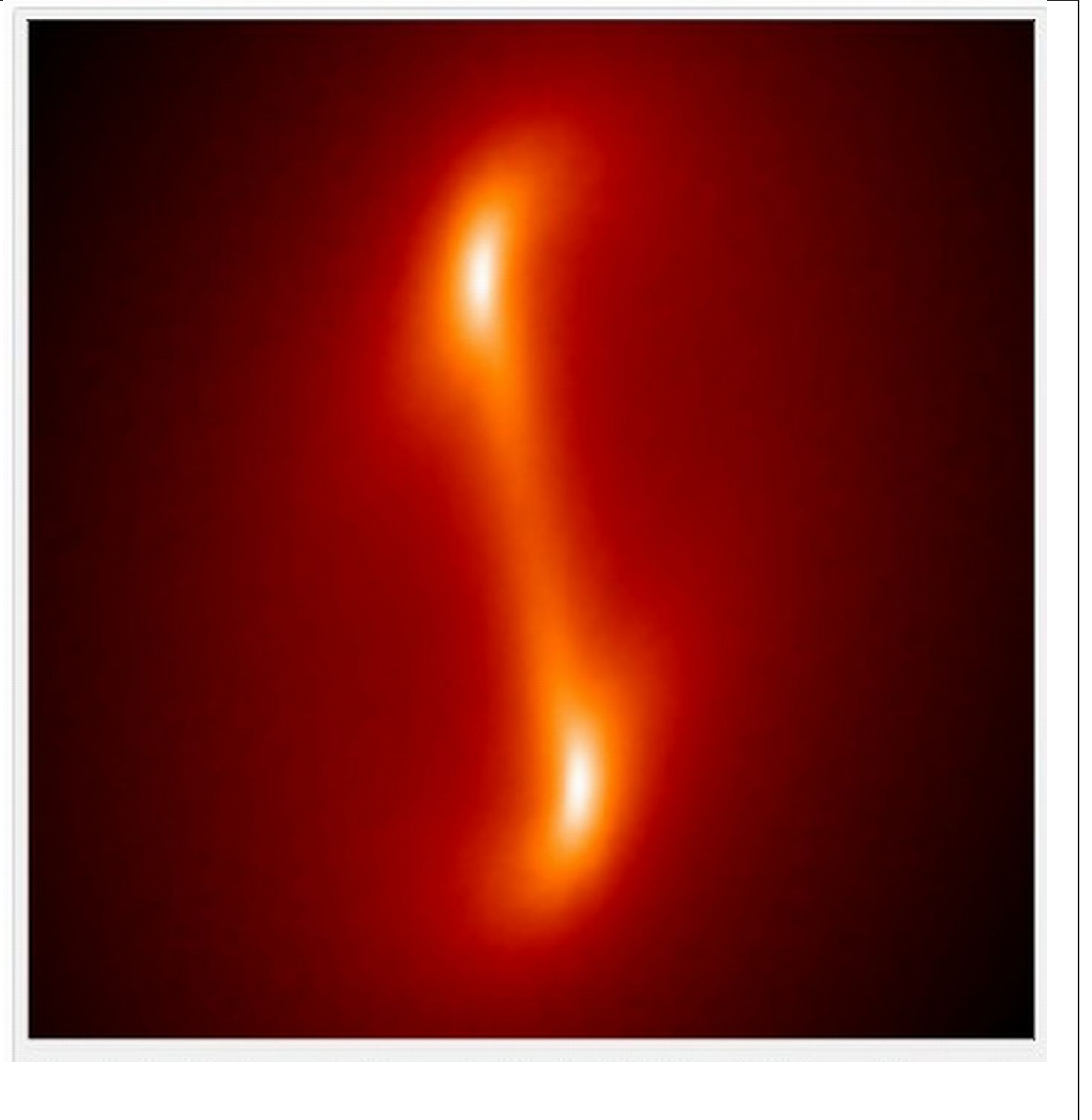
**3.2 COSMICS** - a package of FORTRAN programs useful for *computing transfer functions and microwave background anisotropy for cosmological models*, and for generating gaussian random initial conditions for nonlinear structure formation simulations of such models. **Four programs are provided**: (1) `linger_con` and `linger_syn` integrate the linearized equations of general relativity; (2) `matter`, and radiation in conformal Newtonian and synchronous gauge, respectively; (3) `deltat` integrates the photon transfer functions computed by the `linger` codes to produce photon anisotropy power spectra; (4) `graphic` tabulates normalized matter power spectra and produces constrained or unconstrained samples of the matter density field.



3.3 FASTELL - a code *to calculate quickly and accurately the lensing deflection and magnification matrix* for the softened power-law elliptical mass distribution (SPEMD) lens galaxy model. The *SPEMD consists of* a softened power-law radial distribution with elliptical isodensity contours. Because of their simplicity, axisymmetric mass distributions are often used to model gravitational lenses. Since galaxies are usually observed to have elliptical light distributions, mass distributions with elliptical density contours offer more general and realistic lens models.



**3.4 GADGET** - a freely available code for **cosmological *N*-body/SPH simulations** on massively parallel computers with distributed memory. The code can be run on essentially all supercomputer systems presently in use, including clusters of workstations or individual PCs. *GADGET computes gravitational forces with a hierarchical tree. It follows the evolution of a self-gravitating collisionless *N*-body system, and allows gas dynamics to be optionally included.*



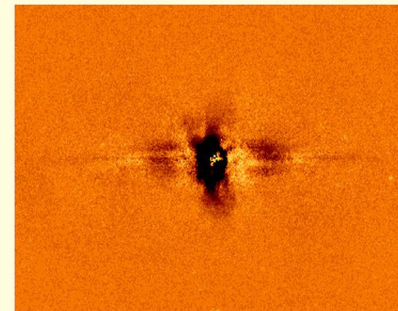
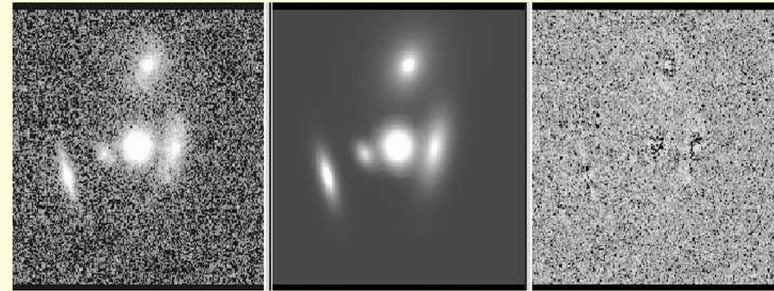
**3.5 GALACTICUS** – a project, led by Andrew Benson, aims to **build a comprehensive model of galaxy formation**. Galacticus is *designed to solve the physics involved in the formation of galaxies within the current standard cosmological framework*. It is of a type of model known as "semi-analytic" in which the numerous complex non-linear physics involved are solved using a combination of analytic approximations and empirical calibrations from more detailed, numerical solutions. Models of this type aim to begin with the initial state of the Universe (specified shortly after the Big Bang) and apply physical principles to determine the properties of galaxies in the Universe at later times, including the present day. *Typical properties computed include the mass of stars and gas in each galaxy, broad structural properties (e.g. radii, rotation speeds, geometrical shape etc.), dark matter and black hole contents, and observable quantities such as luminosities, chemical composition, etc.*



### 3.6 GALFIT

A two-dimensional (2-D) fitting algorithm designed to **extract structural components from galaxy images**, with emphasis on closely **modelling light profiles of spatially well-resolved, nearby galaxies** observed with the Hubble Space Telescope. **2-D models such as the "Nuker" law, the Sersic (de Vaucouleurs) profile, an exponential disk, and Gaussian or Moffat functions are used.** The azimuthal shapes are generalized ellipses that can fit disk and boxy components. Many galaxies with complex isophotes, ellipticity changes, and position-angle twists can be modeled accurately in 2-D.

#### GALFIT Home Page



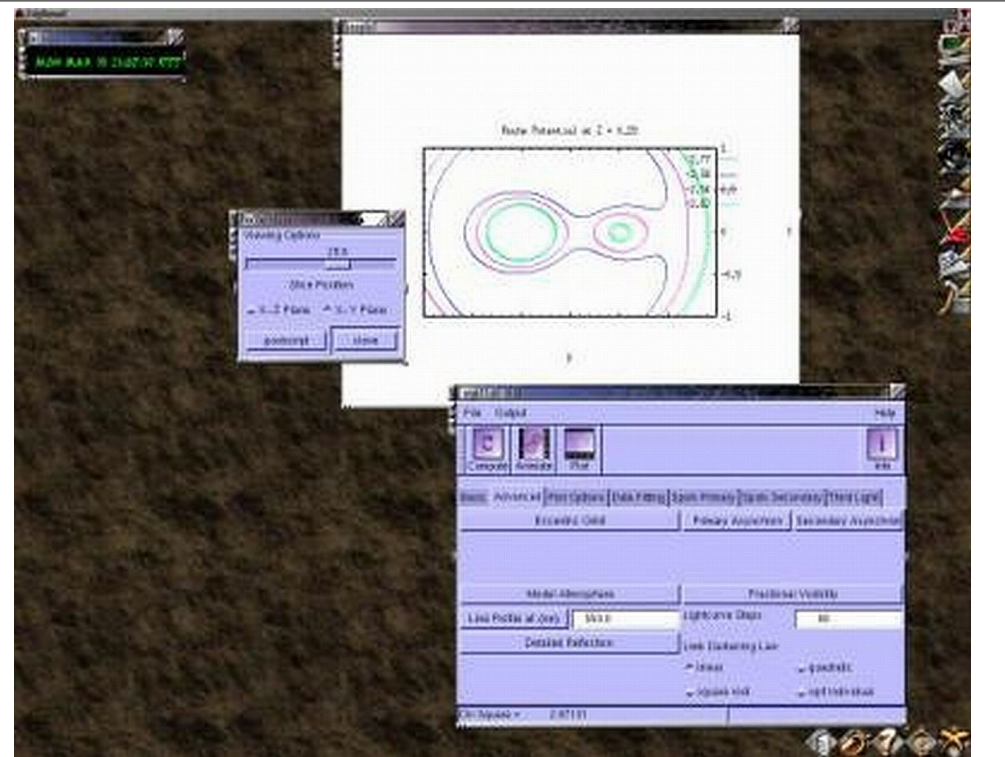
Animation: GALFIT takes away the subcomponents of NGC 4111 layer by layer.

*This is illustrated by way of **seven case studies**, which include regular and barred spiral galaxies, highly disk lenticular galaxies, and elliptical galaxies displaying various levels of complexities.*

### 3.7 N-BODY simulations - nbody\_sh1p - *a parallel direct N-body code.*

**Educational N-body integrator** with a shared but variable time step (the same for all particles but changing in time), using the Hermite integration scheme. **Typical command line** (generates n24body.out) : `*%* nbody_sh1p < n24body.in > n24body.out`

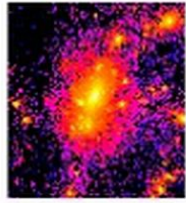
**3.8 NIGHTFALL** is an astronomy application for fun, education, and science. It *can produce animated views of eclipsing binary stars, calculate synthetic light curves and radial velocity curves, and eventually determine the best-fit model for a given set of observational data of an eclipsing binary star system.* Nightfall comes with a user guide, and a set of observational data for several eclipsing binary star systems.



**3.9 PANDORA** - Pandora is a *general-purpose non-LTE computer program for calculating stellar atmosphere models and detailed line and continuum spectra*. Recent applications include extensive modeling of the outer atmosphere of the Sun and other late-type stars, including effects of mass flows; the atmospheric response to external ionizing radiation; and the effects of ion diffusion.

**3.10 SYNSPEC** - is a *general spectrum synthesis program*. It assumes an existing model atmosphere, calculated previously with *TLUSTY* or taken from the literature, for instance from the Kurucz grid of models. The opacity sources (continua, atomic and molecular lines) are fully specified by the user. An arbitrary stellar rotation and instrumental profile can be applied to the synthetic spectrum. *Synplot* is a user-friendly IDL wrapper around Synspec. Synplot is keyword-driven and incorporates all the necessary plotting resources for spectral analysis (see 3.12 TLUSTY)

**3.11 TIPSYS** - the **T**heoretical **I**mage **P**rocessing **S**ystem. *Display and analyze the results of N-body simulations.*



# University Of Washington

## N-BODY SHOP

### Tipsy Gallery

---

*TIPSY* is a special package built to could **easily perform the following functions**: Display particle positions (as points), and velocities (as line segments) from an arbitrary viewpoint; Zoom in to a chosen position. Due to their extremely clustered nature, structure of interest in an N-body simulation is often so small that it can not be seen when looking at the simulation as a whole; Color particles to display scalar fields. Examples of such fields are potential energy, or for SPH particles, density and temperature; Selection of a subset of the particles for display and analysis; Following selected particles from one timestep to another; Finding cumulative properties of a collection of particles. This usually involves just a sum over the particles.

**The basic data structure is an array of particle structures.** Since *TIPSY* was built for use with cosmological N-body simulations, there are actually **three separate arrays for each of the types of particle used in such simulations: collisionless particles, SPH particles, and star particles.**



**3.12 TLUSTY** - The present set of computer programs is *a package designed to accomplish a wide range of spectroscopic diagnostics*. In its maximum configuration, the user may start from scratch and calculate a model atmosphere of a chosen degree of complexity, and end with a synthetic spectrum in a wavelength region of interest for an arbitrary stellar rotation and an arbitrary instrumental profile. The user may also *model the vertical structure of annuli of an accretion disk*.



*Welcome to Tlusty's Home Page!*

Ivan Hubeny & Thierry Lanz

---

A user-oriented package for modeling stellar atmospheres and accretion disks  
and for stellar spectroscopic diagnostics

---



*Welcome to Synspec's Home Page!*

Ivan Hubeny & Thierry Lanz

---

A user-oriented package for modeling stellar atmospheres  
and for stellar spectroscopic diagnostics

---

## **4. Organizers**

**4.1 APT** - write, validate and submit proposals for the Hubble Space Telescope

**4.2 CONSKY** – answers the question of what resources are needed to produce a continuous data record of the entire sky down to a given limiting visual magnitude

**4.3 FITS viewers** -

**4.4 GASGANO-ESO** - a Data File Organizer to manage and organize the astronomical data observed and produced by all VLT compliant telescopes

**4.5 HERA** - provides many general utility programs for manipulating FITS format images and tables

**4.6 SKYCAL** - The astronomical calendars program

**4.7 WCSTOOLS** - a package for setting and using the world coordinate systems (WCS) in the headers of the most common astronomical image formats.

## 4.1 APT - The Astronomer's Proposal Tool

# Hubble Space Telescope Astronomer's Proposal Tool

The **Astronomer's Proposal Tool** (APT) is used to write, validate and submit proposals for the Hubble Space Telescope. (It will also be used eventually for James Webb Space Telescope proposals.) APT is an integrated toolset consisting of editors for filling out proposal information, an Orbit Planner for determining feasibility in Phase II, a Visit Planner for determining schedulability, diagnostic and reporting tools, a Bright Object Tool for performing bright object checks, and an integrated tool based on Aladin for viewing exposure specifications overlaid on FITS images and querying the HST Archive.

The APT installers and documentation are available on the right hand side of this page. "Training Materials" is a compact table of contents of all APT documents. The "Roadmaps" are step-by-step guides to the proposal process with links to both proposal and APT documentation.

**4.2 CONSKY** - This program addresses the question of *what resources are needed to produce a continuous data record of the entire sky down to a given limiting visual magnitude.* The program simulates a small camera/telescope or group of small camera/telescopes collecting light from a large portion of the sky. From a given stellar density derived from a Bahcall - Soneira Galaxy model, the program first converts star densities at visual magnitudes between 5 and 20 to number of sky pixels needed to monitor each star simultaneously. From pixels, *the program converts input CCD parameters to needed telescope attributes, needed data storage space, and the length of time needed to accumulate data of photometric quality for stars of each limiting visual magnitude over the whole sky.* The program steps through photometric integrations one second at a time and includes the contribution from a bright background, read noise, dark current, and atmospheric absorption.

**4.3. FITS viewers** – see next slide...





---

## FITS Image Viewers and Format Converters

---

### FITS Image Viewers

- [SAOImage ds9](#) - astronomical visualization application from SAO
- [fv](#) - FITS file viewer and editor (supports FITS images and FITS tables)
- [FITSview](#) - FITS image viewer from NRAO
- [SkyCat](#) - ESO tool combines image visualization and access to catalogs
- [GAI](#) - an image display and analysis tool from the U.K. Starlink Project. It is a derivative of the ESO SkyCat tool
- [Aladin](#) - Interactive Sky Atlas
- [APLpy](#) - Astronomical Plotting Library in Python is a Python module aimed at producing publication-quality plots of astronomical imaging data in FITS format.
- [qiv](#) - A cross platform (posix and Windows) image viewer designed especially for scientific vision and computational geometry. Supports interactive brightness and contrast adjustment of 2D images and 3D cubes in various data formats, including FITS. Also supports drawing vector graphics on top of the image.
- [PhAst](#) - A flexible IDL tool to display and analyze FITS images. It can calibrate raw images, provide astrometric solutions, and do circular aperture photometry. PhAst allows the user to load, process, and blink any number of images. Requires either an IDL license, or installation of the (free) IDL Virtual Machine.
- [QFitsView](#) - An image viewer for 1-D, 2-D, and 3\_D FITS images. It is written in C++ and uses the Qt widget library. Binary executables for Microsoft Windows, Linux, and Mac OSX, as well as the source code, are available.
- [Libvips](#) - a fully demand-driven, threaded image processing library with no image size limits and with good support for colour. Reads and writes FITS images, as well as TIFF, JPEG, PPM, PNG, and other file formats. Has interfaces to C, C++ and Python, and a command-line interface that can be called from shell scripts.

### Image Format Converters - FITS to/from GIF, JPEG, etc

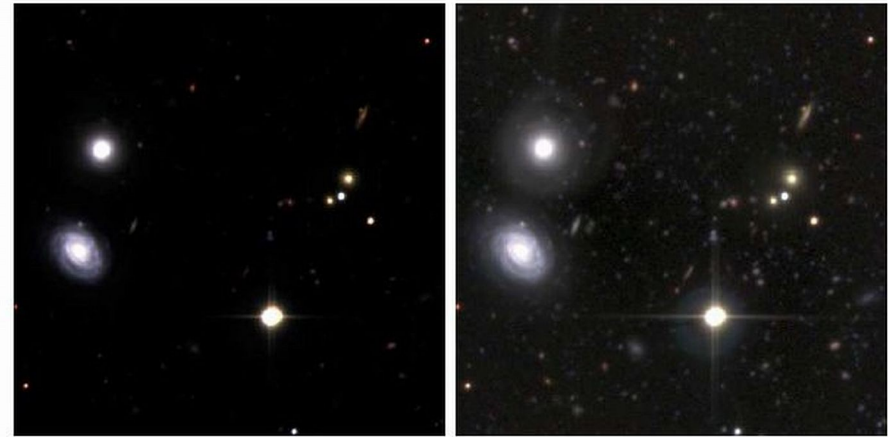
- [Netpbm](#) - a package of graphics programs and programming library. The [documentation](#) is on-line. In particular, see the [fitstopnm](#) and [pnmtofits](#) programs. To first order, the following command converts a jpeg image to a FITS image on most Linux systems:  

```
djpeg file.jpg | pnmtofits > file.fits
```

where "djpeg" is available in the libjpeg RPM package.
- [ImageMagick](#) - read, write, and manipulate images in over 68 formats
- [pbmplus](#) - image file format conversion package
- [gimp](#) - GNU Image Manipulation Package
- [FITS2jpeg](#) - a FITS to jpeg converter provided by Bill Cotton (NRAO). It needs the CFITSIO and libjpeg libraries and produces grayscale images.
- [SAOImage ds9](#) - this FITS visualization application from SAO allows the image to be saved as a jpeg, tiff, png, or ppm file on disk (use File->Save)
- [MicroObservatory Image 2.0](#) - Image display and processing program can perform FITS to GIF conversion and create RGB color images or animated GIF files.
- [fts2gif](#) - a simple FITS to gif converter written by Michal Szymanski (Warsaw University Observatory). It requires the "raw2gif" application from the giflib-3.0 library (Linux and Solaris versions of raw2gif are included in the fts2gif tar file).

4.3.1 *STIFF* is a program that **converts scientific FITS images to the more popular TIFF format** for illustration purposes.

Last version – 2.1 was included in ALADIN.  
2010, E. Bertin.



The same 3 R,G and B deep-sky images processed by FITS LIBERATOR (left) and STIFF (right), using the same intensity cuts.

#### 4.4 GASGANO



### Gasgano Reaching New Heights in Astronomy

Gasgano is a Data File Organiser developed and maintained by ESO to help its user community to manage and organise in a systematic way the astronomical data observed and produced by all VLT compliant telescopes, i.e. by telescopes which are being operated through Observation Blocks. The tool also supports FITS files which are not generated by those telescopes but with a limited number of functionalities. For further information, please, refer to the latest [Gasgano User's Manual](#).

4.5 HERA - The Hera data processing facility provides *many general utility programs for manipulating FITS format images and tables*. These general tools are organized into *several different FTOOLS packages*:

- ⋆ **HEATTOOLS** - tasks for *listing, editing* and calculating statistics about any FITS file, image processing calculators, and *general table manipulation tools* (sorting, appending, selecting rows, etc.)
- ⋆ **FIMAGE** - utilities for general *image processing and manipulation*.
- ⋆ **FUTILS** - a large set of general FITS utility program mainly for *manipulating FITS headers or tables*; some of these are older versions of tools in the HEATTOOLS package.

*Hera also provides hundreds of more specialized programs, mainly for professional researchers, to analyze data from high-energy astrophysics missions such as ROSAT, Chandra, XMM-Newton, Swift, and Suzaku.* Currently, these tools include all the hundreds of programs in the HEASARC FTOOLS and the Chandra CIAO data analysis packages, as well as several of the most frequently used programs in the XMM-Newton SAS package.



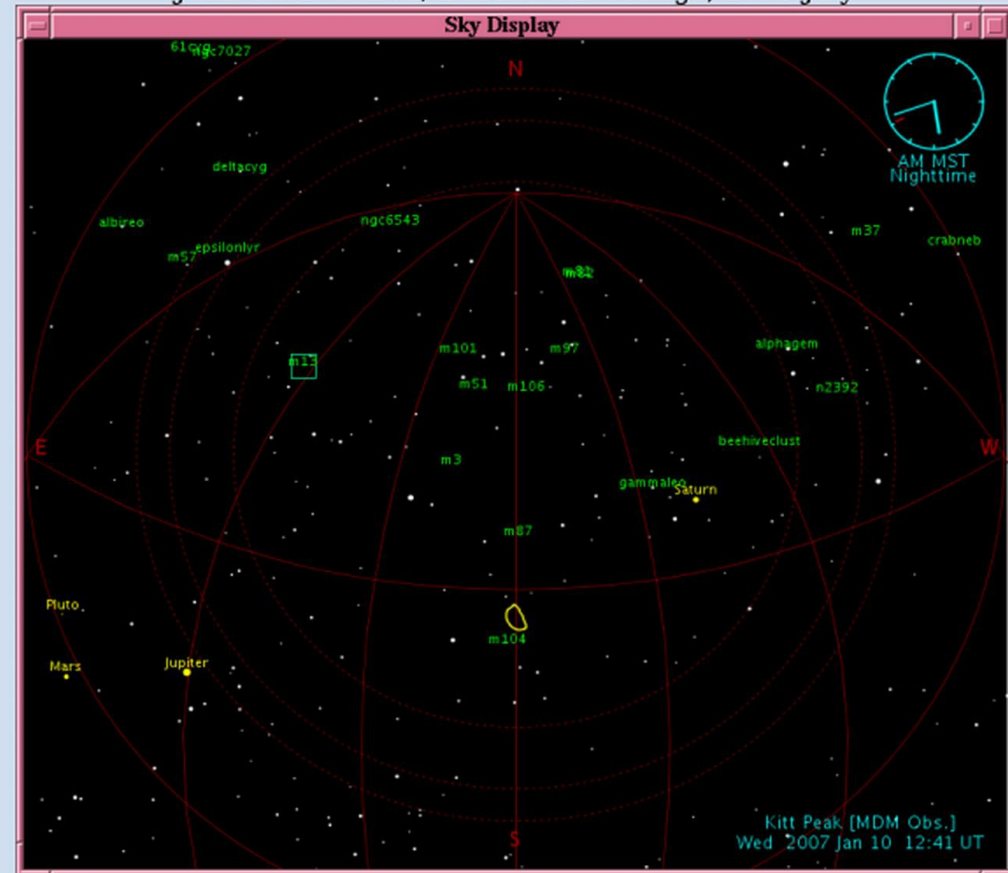
## 4.6 SKYCAL – *in fact a two different programs:*

**Skycalc** is an interactive tool which conveniently handles the time-and-the-sky calculations commonly encountered in optical astronomy. It has many features useful **for planning observations** at the telescope.

**Skycalendar** prints **a table of sunrise, sunset, moonrise, moonset, and so on,** organized on a nightly (double-dated) basis for any site.









Ver.6 and newer have a GUI interface too. *The picture shows JAVA version of the SkyCalc.*

JSkyCalc -- A Convenient, Portable Observing Aid  
John Thorstensen, Dartmouth College; 2008 July



**4.7 WCSTOOLS - a package of programs and a library of utility subroutines for *setting and using the world coordinate systems (WCS) in the headers of the most common astronomical image formats, FITS and IRAF .imh, to relate image pixels to sky coordinates.*** This software is all written in very portable C, so it should compile and run on any computer with a C compiler. The current (2011) version is 3.8.1.

The current version is 3.8.4

	<ul style="list-style-type: none"> <li>• Handles all FITS image data types: 8-bit unsigned integer, 16- and 32-bit signed integer, 32- and 64-bit IEEE floating point, plus non-standard 16-bit unsigned integer (BITPIX=-16).</li> <li>• Accesses IRAF .imh (versions 1 and 2) files as well as FITS files</li> <li>• Uses any of several reference catalog formats from CDROMs or identically-structured online files,</li> <li>• Uses the standard <a href="#">SAO/NRAO world coordinate system library</a> or Mark Calabretta's <a href="#">WCSSLIB library</a>, which defines the proposed FITS WCS standard.</li> <li>• <b>Is Y2K-compliant</b></li> <li>• <b>Implements images with more than one WCS</b></li> <li>• Uses same WCS subroutines as <a href="#">SAOImage</a>, <a href="#">SAOimg</a>, <a href="#">ds9</a>, and <a href="#">skycat</a> image browsing programs.</li> <li>• Can be installed as an IRAF package</li> </ul>
	<ul style="list-style-type: none"> <li>• <b>Image WCS</b> (<a href="#">imwcs</a>) (<a href="#">remap</a>) (<a href="#">sky2xy</a>) (<a href="#">xy2sky</a>) (<a href="#">SAOImage</a>) [<a href="#">Getting Good Coordinates</a>]</li> <li>• <b>Catalogs and Image WCS</b> (<a href="#">imcat</a>) (<a href="#">imstar</a>) [<a href="#">Environment Variables</a>]</li> <li>• <b>Image Header Utilities</b> (<a href="#">delhead</a>) (<a href="#">edhead</a>) (<a href="#">gethead</a>) (<a href="#">imhead</a>) (<a href="#">unsiz</a>) (<a href="#">keyhead</a>) (<a href="#">sethead</a>)</li> <li>• <b>Image Utilities</b> (<a href="#">getfits</a>) (<a href="#">getpix</a>) (<a href="#">l2f</a>) (<a href="#">newfits</a>) (<a href="#">setpix</a>) (<a href="#">sumpix</a>)</li> <li>• <b>Catalog Utilities</b> (<a href="#">imcat</a>) (<a href="#">scat</a>) (<a href="#">skycoor</a>)</li> </ul>
	<ul style="list-style-type: none"> <li>• USNO-B1.0 Catalog</li> <li>• HST GSC II</li> <li>• HST GSC and GSC-ACT Catalogs</li> <li>• USNO-A2.0, SA2.0, and UCAC2 Catalogs</li> <li>• 2MASS Point Source Catalog</li> <li>• Copenhagen/USNO Tycho-2 Catalog</li> <li>• Local catalogs in Starbase, ASCII, or SAO TDC binary format</li> <li>• <a href="#">Environment variables for catalog paths</a></li> </ul>
	<ul style="list-style-type: none"> <li>• <a href="#">World Coordinate System Subroutines</a></li> <li>• <a href="#">Source Catalog Access Subroutines</a></li> <li>• <a href="#">Image I/O and Access Subroutines</a></li> <li>• <a href="#">Processing Subroutines</a></li> </ul>
	<ul style="list-style-type: none"> <li>• Anonymous FTP from <a href="ftp://cfa-ftp.harvard.edu/pub/gsc/WCSTools/">ftp://cfa-ftp.harvard.edu/pub/gsc/WCSTools/</a> (A legitimate domain name is needed as the password, if you have problems retrieve the package via http:.)</li> <li>• HTTP from <a href="http://tdc-www.harvard.edu/software/wcstools/wcstools-3.8.4.tar.gz">http://tdc-www.harvard.edu/software/wcstools/wcstools-3.8.4.tar.gz</a></li> <li>• You can retrieve a subset of the WCSTools subroutines which are needed for WCS conversion from <a href="http://tdc-www.harvard.edu/software/wcstools/wcsubsub-3.8.4.tar.gz">http://tdc-www.harvard.edu/software/wcstools/wcsubsub-3.8.4.tar.gz</a></li> <li>• If you are on a C/P-managed system at the CFA, add /data/oir/wcs/bin.redhat for Redhat Linux machines to your search path.</li> <li>• Pete Ratzlaff has put together a Perl interface to the WCSTools libraries called <a href="#">Astro-WCS-LibWCS-0.9.0</a>.</li> </ul>
	<ul style="list-style-type: none"> <li>• WCS subroutines: <a href="#">D.Mink(1995), ADASS V [full text]</a></li> <li>• Entire package: <a href="#">D.Mink(2001), ADASS XI, D.Mink(1996), ADASS VI [full text]</a></li> <li>• <a href="#">D.Mink(1998), AAS/DDA meeting, D.Mink(1998), ADASS VIII [full text]</a></li> </ul>
	<p>Some subroutines in the library have been adapted and amplified from software originally written by Elwood Downey of the <a href="#">University of Iowa Automated Telescope Facility</a>, Bill Cotton of the U.S. <a href="#">NRAO</a>, Mark Calabretta of the Australian <a href="#">CSIRO</a>, and Pat Wallace of the <a href="#">UK Starlink Project</a>. Others are translated from the Fortran code I wrote to support the <a href="#">star</a> and <a href="#">skymap</a> programs.</p>
	<p>This software was originally inspired by the impending standardization of WCS keywords in FITS as discussed at the 1994 ADASS Conference. The subroutines to translate between sky and image coordinates came first, then the utilities to use them, and then the programs to search catalogs and fit a world coordinate systems to images.</p>

Last updated 30 December 2011 by [Jessica Mink](#) [email]

## ***5. Planetariums software***

**5.1 CELESTIA** - a free space simulation

**5.2 KSTARS** - a Desktop Planetarium for KDE

**5.3 OPENUNIVERSE** - simulates the Solar System's bodies in 3D

**5.4 SKYVIEW.CAFE** - a Java applet to see many types of astronomical information in both graphical and numerical form

**5.5 STELLARIUM** - a free open source planetarium

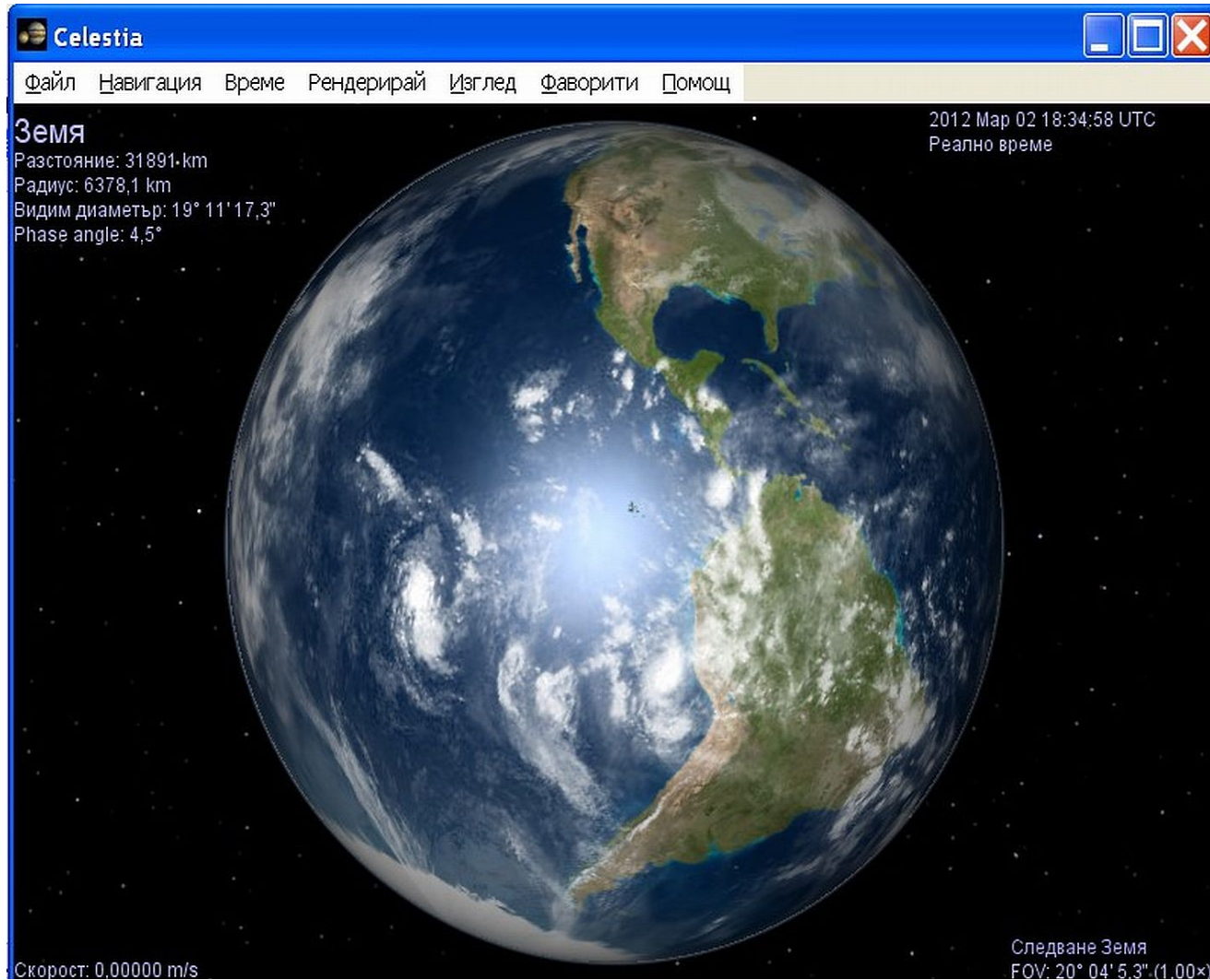
**5.6 XEPHEM** - a scientific-grade interactive astronomical ephemeris package

**5.7 XPLNS** - reproduces real starry sky on your display of X Window System

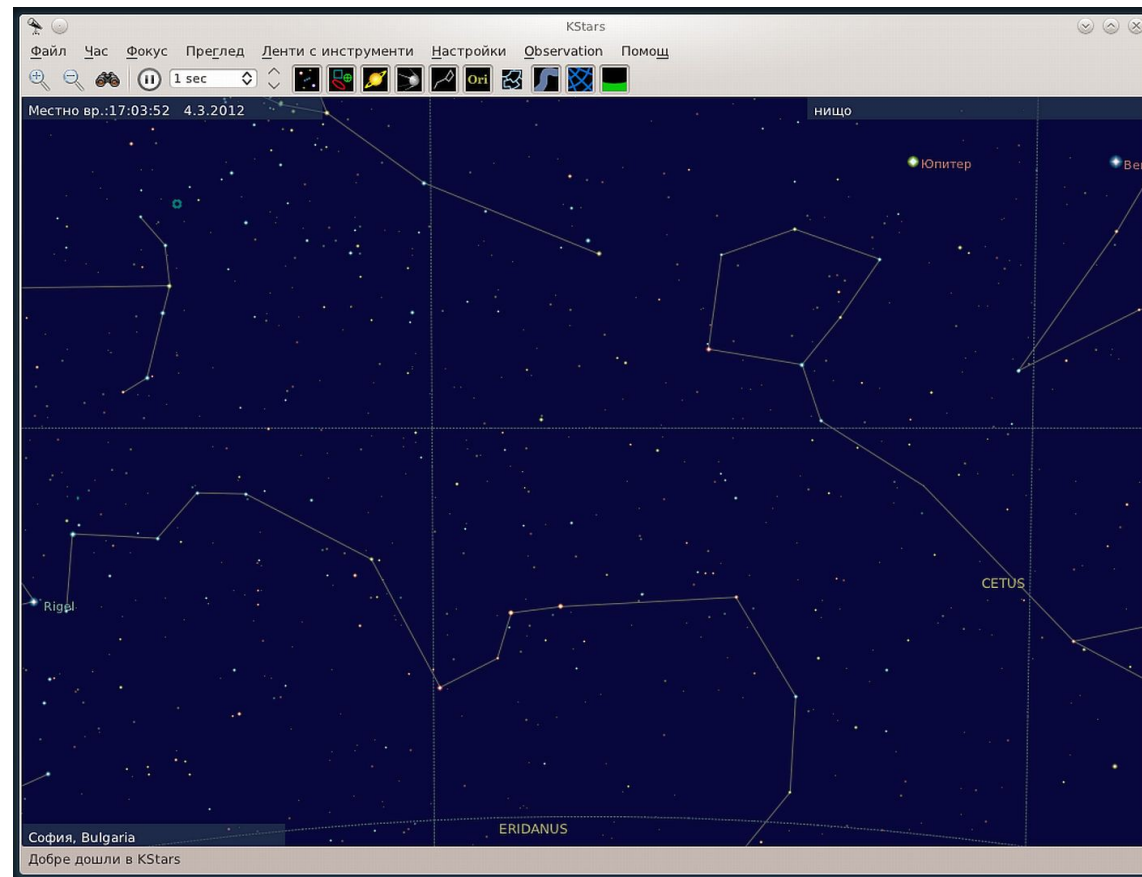
**5.8 XSKY** - makes the use of machine-readable astronomical object catalogues

**5.9 XVMOONTOOL** - displays information about the moon in real time.


**5.1 CELESTIA** is a free **real-time space simulation** that lets you visually experience our universe in three dimensions.



**5.2 KSTARS - *a Desktop Planetarium for KDE*.** It provides an accurate graphical simulation of the night sky, from any location on Earth, at any date and time. ***The display includes upto 100 million stars, 13,000 deep-sky objects, all 8 planets, the Sun and Moon, and thousands of comets and asteroids.***



## 5.3 OPENUNIVERSE



The image shows a screenshot of the 'Open Universe' software. It features a 3D rendering of Saturn with its prominent ring system. The planet is yellowish, and the rings are grey and semi-transparent. The background is black, representing space. There are some small text elements in the top-left and bottom-left corners of the window, likely technical data or controls.

### Open Universe

Strictly spoken it's a piece of software, simulating the Solar System's bodies in 3D on your Windows or Linux PC (will work in most \*NIX's as well). In difference to quite a few other programs it does so in realtime. Meaning you can view all the planets, moons and spaceships *move* along their paths, trace them, follow them, orbit them and even control them (time and spaceship control). And you won't have to fight your way through hordes of green, slimey and one-eyed aliens for that ;-)

**5.4 SKYVIEW.CAFE** - Sky View Cafe is ***a Java applet that lets you see many types of astronomical information in both graphical and numerical form.*** Sky View Café includes star charts, a 3-D orderly, displays of the moons of Jupiter and Saturn, an astronomical event calendar, an ephemeris generator, and many other features.

sky view café v5.6.0

about help java

Download Sky View Café to use offline. PayPal DONATE

Now 2012-01-12 10:12 +02:00  Track current time

← Rising of Sun → More...

±YYYY-MM-DD HH:mm previous/next event

Moons/GRS Insolation Map Calendar Time Tables

Sky Ecliptic Orbits

Select a direction... S ...or drag view below.  Track Sun

Right-click objects for more info

Location Settings

42°43'N 023°20'E  
latitude longitude

Europe  
time zone region/category

Athens  
specific time zone

SOFIA, BG

Find... Save... Delete...

Options

Full Sky - Flat

Sky Color: Multicolor

No asteroids or comets

Refraction effect

Celestial grid

Ecliptic grid

Path of Sun, ±12h

Path of Moon, ±12h

Brighten stars

Constellations

Enlarge Sun/Moon

Milky Way

Show Names...

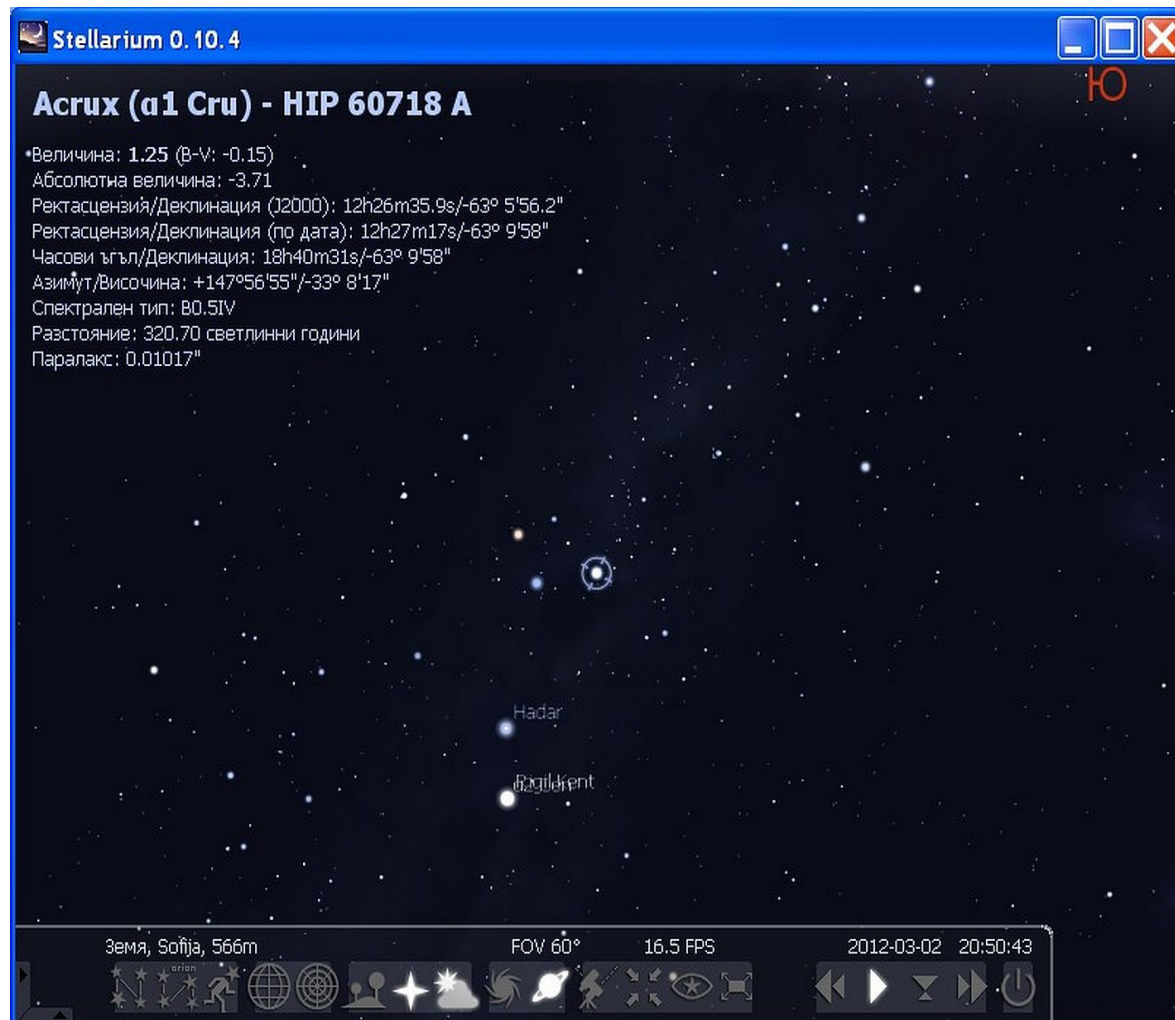
+ Share • f g+ st • Discuss on facebook

Sky View Café © 2000-2012 Kerry Shetline.

## 5.5 STELLARIUM

- a free **open source planetarium** for your computer. It shows a realistic sky in 3D, just like what you see with the naked eye, binoculars or a telescope. *It is being used in planetarium projectors.*

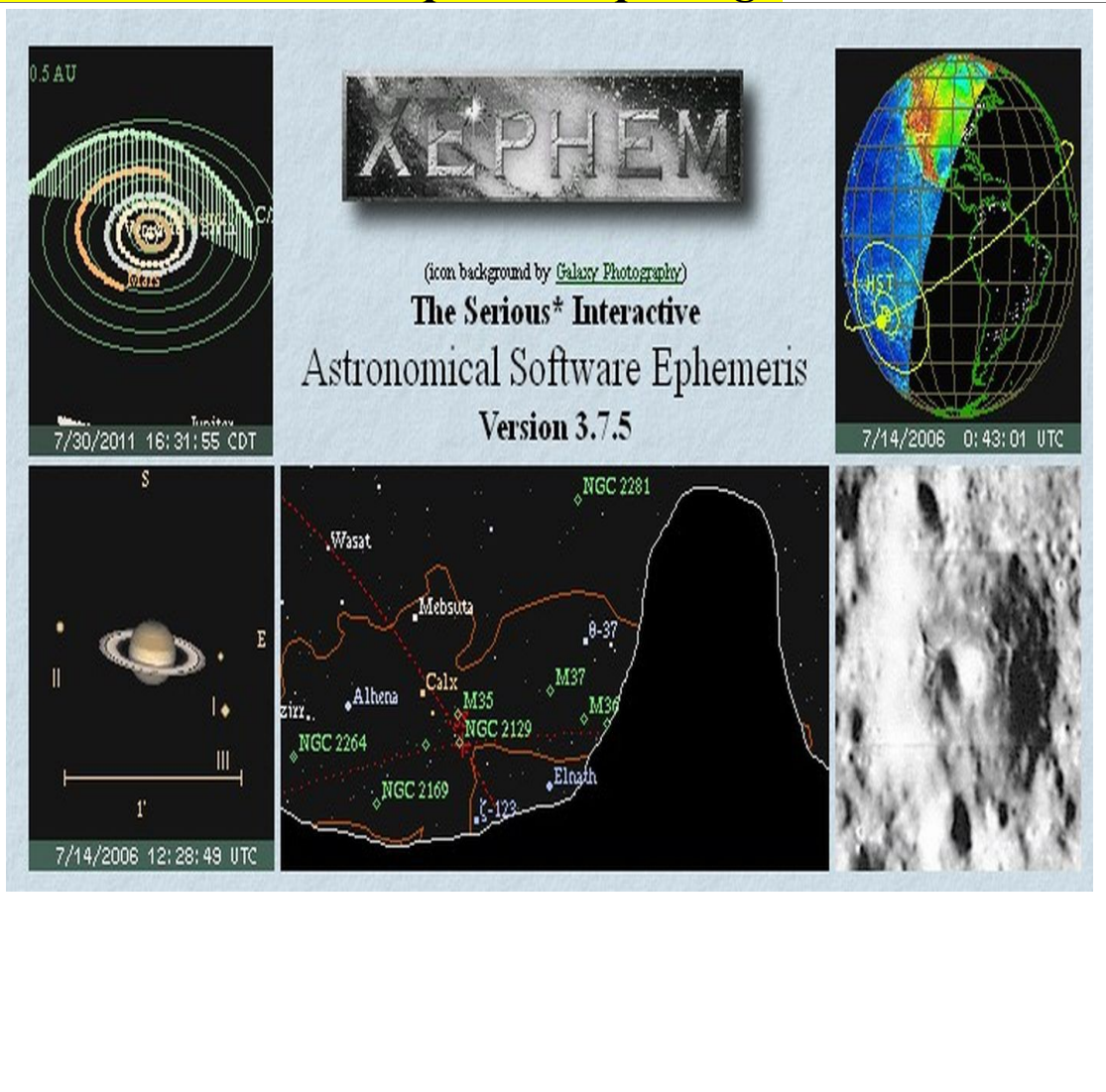
**Stellarium** includes: **default catalogue of over 600,000 stars**; *extra catalogues with more than 210 million stars*; *asterisms and illustrations of the constellations*; **constellations for twelve different cultures**; **images of nebulae (full Messier catalogue)**; *realistic Milky Way*; *very realistic atmosphere, sunrise and sunset*; *the planets and their satellites...*



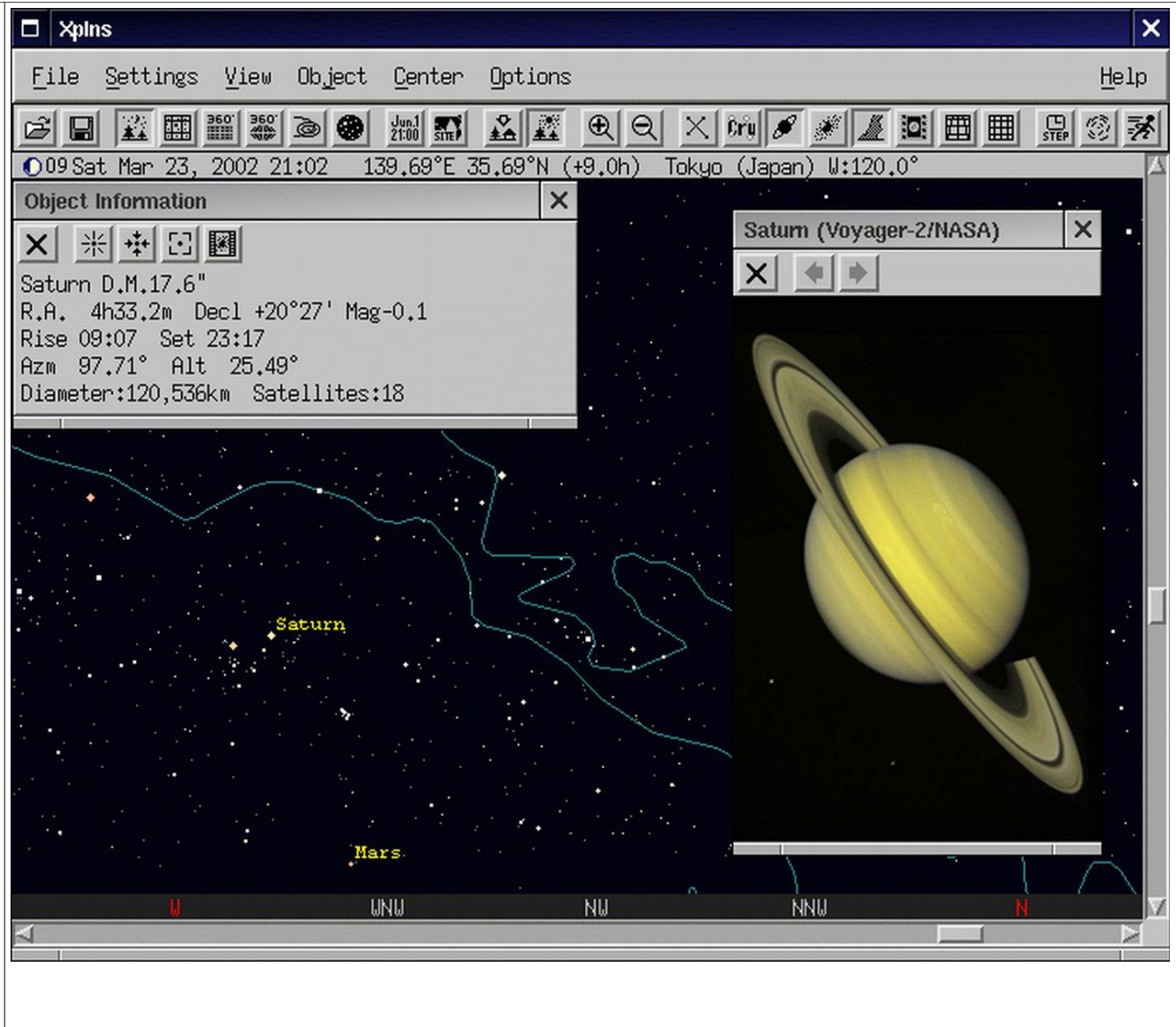


## 5.6 XEPHEM - a *scientific-grade interactive astronomical ephemeris package*.

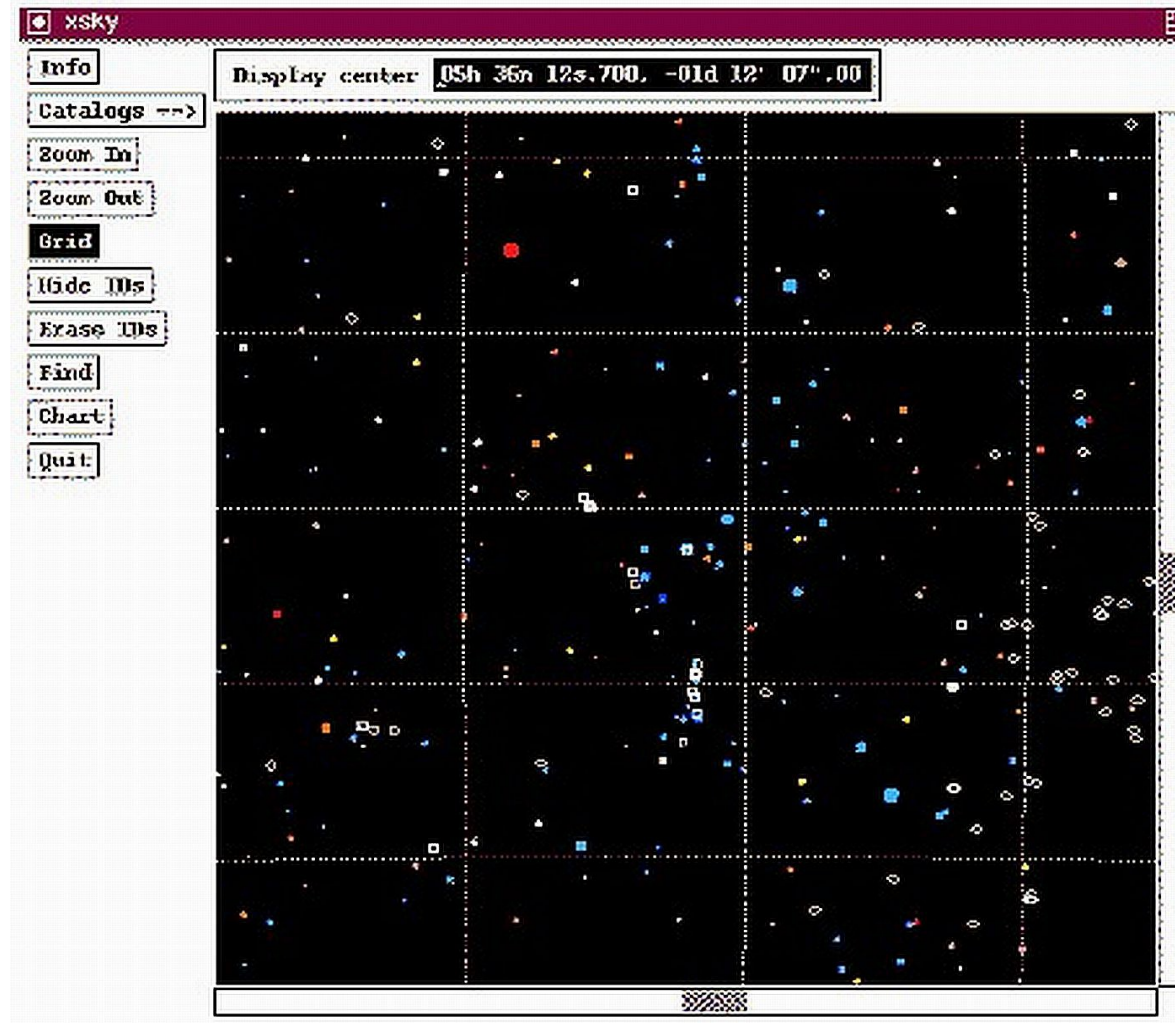
XEphem: *computes* heliocentric, geocentric and topocentric information for all objects; has built-in support for all planets; the moons of Mars, Jupiter, Saturn, Uranus and Earth; **downloads Digitized Sky Survey FITS files from STScI or ESO overlaid with database symbols and other graphical information**; provides a handy coordinates spreadsheet for converting among equatorial, ecliptic, horizon and galactic frames; **performs automatic star pattern matching to automatically solve for World Coordinate System** on any image and many others.



**5.7 XPLNS** - reproduces real starry sky on your display of X Window System. It **calculates the position of many celestial objects (stars, galaxies, nebulae, constellations, planets, comets, etc.) very accurately**. There are **fourteen projection mode** in xplns, "Horizontal View Mode", "Equatorial Mode", "Ecliptic Mode", "Galactic Mode", "Planisphere Mode" and "Solar System Mode".



5.8 XSKY - (T.R.Friedrichsen, Sunquest Information Systems) *makes the use of machine-readable astronomical object catalogues* available by the National Space Sciences Data Centre.



## 5.9 XVMOONTOOL - application which *displays information about the moon in real time.*

The screenshot shows a window titled "XVMOONTOOL by John Walker v3.1". The window displays the following information:

- Julian date: 2450581.75414
- Universal time: 18:05:58 12 May 1997
- Local time: 20:05:58 12 May 1997
- Age of moon: 5 days, 20 hours, 13 minutes.
- Moon phase: 33% (0% = New, 100% = Full)
- Moon's distance: 401692 kilometres, 63.0 Earth radii.
- Moon subtends: 0.4958 degrees.
- Sun subtends: 0.5276 degrees.
- Sun's distance: 151162338 kilometres, 1.010 astronomical units.

There is a "Test mode" checkbox which is unchecked. To the right of the text is a small image of the moon showing a crescent phase.

Below the main data, there is a table of moon rise and set times:

Moon rise	Today: 10:17 MET DST	Tomorrow: 11:18 MET DST
Moon set	Today: 00:58 MET DST	Tomorrow: 01:33 MET DST

At the bottom, there is a list of moon phases with their times and lunation values:

☉ Last new moon:	20:48 UTC 6 May 1997	Lunation : 920
☾ First quarter:	10:56 UTC 14 May 1997	
☽ Full moon:	9:16 UTC 22 May 1997	
☾ Last quarter:	7:52 UTC 29 May 1997	
☉ Next new moon:	7:06 UTC 5 June 1997	Lunation : 921

In the background, there is a taskbar with a "xbiff" icon and a moon icon labeled "10d 20h". The window title bar shows "Today" and a dropdown menu.

## ***6. Radio&Interferometry analysis software***

**6.1 AIPS** - calibration, data analysis, image display, plotting of Astronomical Data

**6.2 ASAP** - a spectral line analysis package to reduce spectral-line observations

**6.3 GILDAS** - a collection of software oriented toward (sub-)millimeter radioastronomical applications

**6.4 GIPSY** - an interactive software system for the reduction and display of astronomical data

**6.5 MIRIAD** - a radio interferometry data reduction package, alternative to AIPS

**6.6 SPC** - a spectral Line reduction package for reducing spectral line data from the Parkes and Mopra radiotelescopes

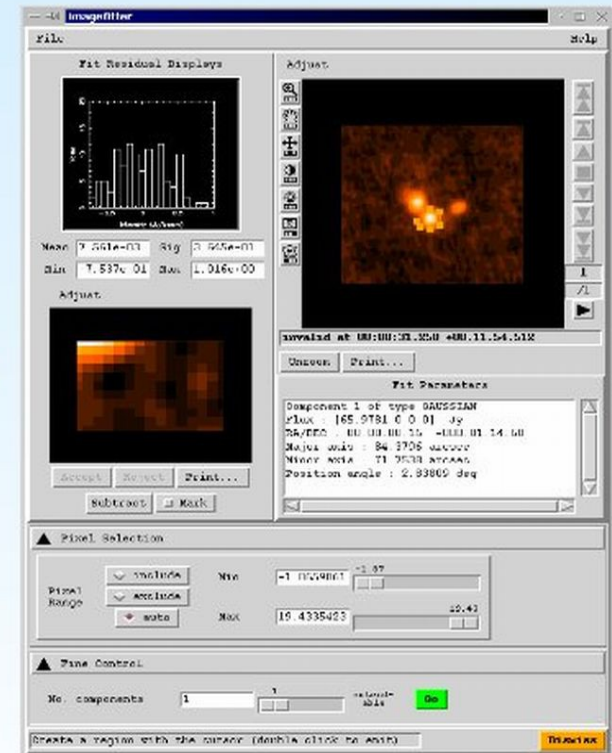
**6.7 SPEXtool** – an IDL-based package for the reduction of spectral data obtained with SpeX IR imager and spectrograph.

**6.1 AIPS** - stands for **Astronomical Image Processing System** for **calibration, data analysis, image display, plotting, and a variety of ancillary tasks on astronomical data**. AIPS is *not recommended for processing mm-wave observations* (30 GHz and higher) from the ATCA, e.g. One should use the [MIRIAD](#) package instead.

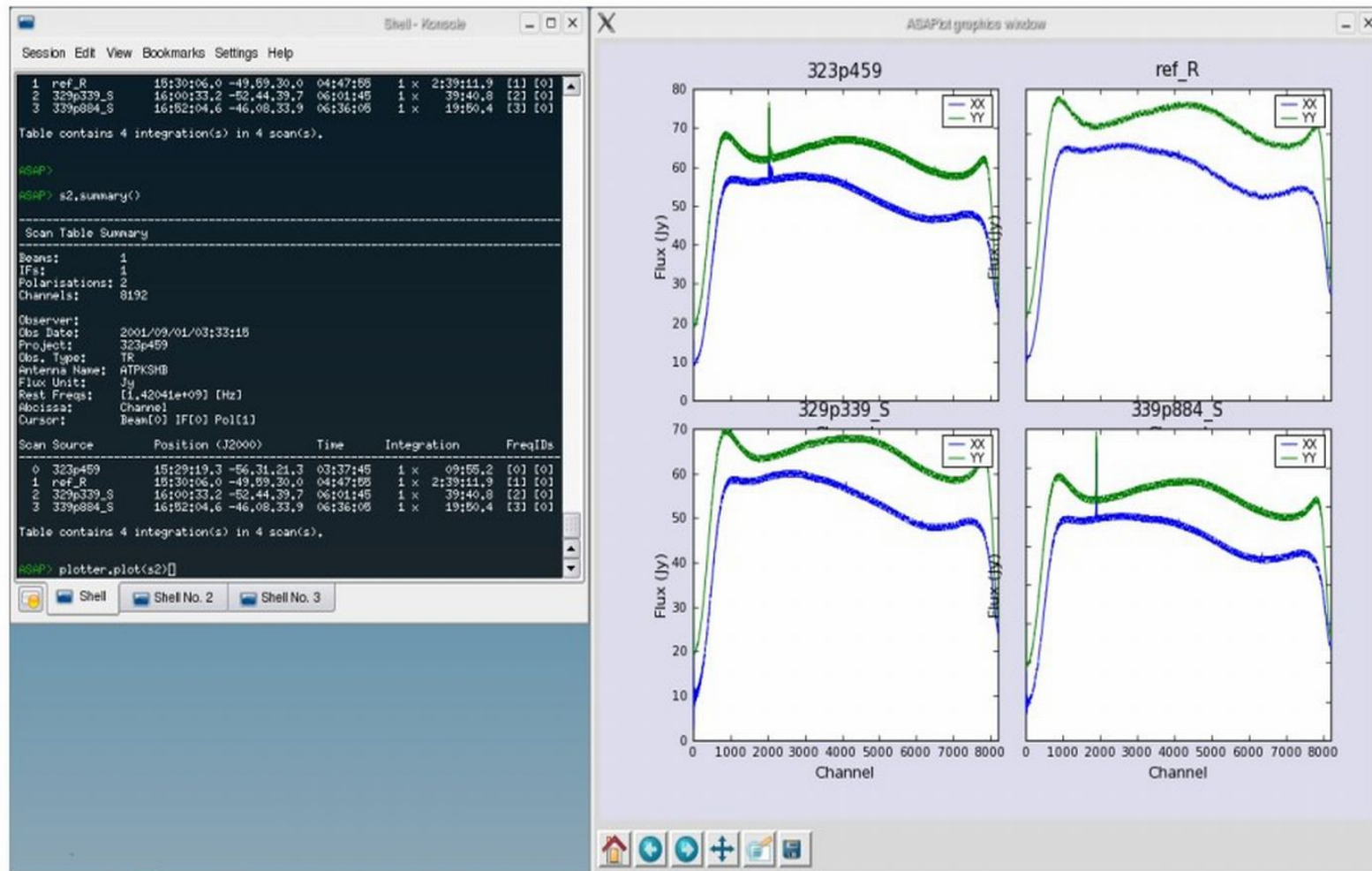
## **AIPS++ Image analysis**

Victoria B.C. 10/01/01

- Image operations
- Convert to and from FITS
  - Very flexible use of “on-the-fly” images
- Display, statistics, histograms, smoothing
- Numerous moment calculation methods
- Image polarization calculations
- Transfer image pixels to and from [Glish](#)
- Image calculator
  - Apply math operations to images, using a syntax based on the AIPS++ Lattice Expression Language
- Integrated with regions
  - Definition, conversion, math of regions in both pixel and world coordinates
    - Coordinate system editing
    - Fast, optimized image [regridding](#)
    - Specialized [mage polarimetry](#)
    - Component fitting



## 6.2 ASAP - an ATNF *Spectral line Analysis package* to reduce single dish, single-pointing spectral-line observations.



## 6.3 GILDAS - Grenoble Image and Line Data Analysis Software.



### INTRODUCTION


GILDAS is a collection of state-of-the-art softwares oriented toward (sub-)millimeter radioastronomical applications (either single-dish or interferometer). It is daily used to reduce all data acquired with the IRAM 30M telescope and Plateau de Bure Interferometer PDBI (except VLBI observations). GILDAS is easily extensible. GILDAS is written in Fortran-90, with a few parts in C/C++ (mainly keyboard interaction, plotting, widgets).

### ACKNOWLEDGMENT IN PUBLICATIONS

The GILDAS team welcomes an acknowledgment in publications using GILDAS software to reduce and/or analyze data.

Please use the following reference in your publications: <http://www.iram.fr/IRAMFR/GILDAS>


## 6.4 GIPSY - a highly interactive software system for the *reduction and display of astronomical data*.



GIPSY

### Groningen Image Processing System

### Kapteyn Institute



This is the home page of the GIPSY online documentation. GIPSY is a highly interactive software system for the reduction and display of astronomical data. This documentation is maintained by [Hans Terlouw](#). E-mail: [J.P.Terlouw@astro.rug.nl](mailto:J.P.Terlouw@astro.rug.nl)



## 6.5 MIRIAD

# MIRIAD

---

**Miriad** is a [radio interferometry](#) data reduction package of particular interest to users of the [Australia Telescope Compact Array](#) (ATCA). It can be used for the reduction of continuum and spectral line observations from beginning to end, starting with the loading of the data (either [FITS](#), the [ATNF RPFITS](#) or old [BIMA](#) formats) through to image synthesis, analysis and display with publication quality graphics.

In particular *Miriad* supports a number of niche areas including calibration and analysis of polarimetric data from the ATCA, multi-frequency synthesis imaging, mosaicing, ATCA pulsar bin mode, and specialized spectral line observations (e.g. Zeeman).

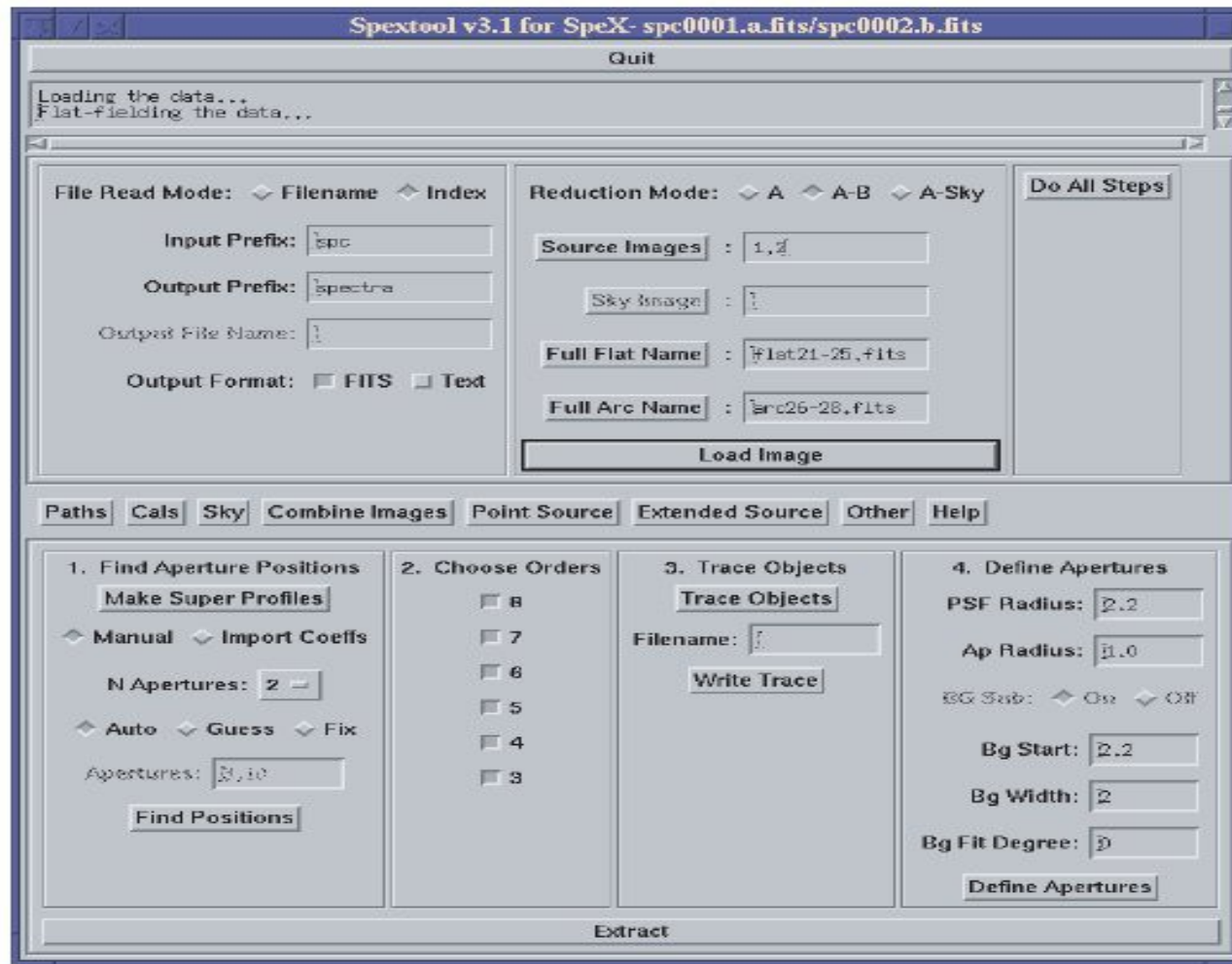
**6.6 SPC - A *Spectral Line Reduction Package*** used for reducing spectral line data from the Parkes and Mopra radiotelescopes. SPC was originally written to process data written by SPECTRA, the spectral-line observing program of the Parkes radiotelescope. The basic idea in using SPC is to *load in a sequence of up to 110 spectra and then use various commands to operate on these spectra.*

**SPC (formerly S)  
A spectral line reduction program  
v3.11.3**

**Rick Forster 1  
Henrietta May 2**

**Simone Magri 3  
Mark Calabretta 4**

**6.7 SPEXtool – an IDL-based package for the *reduction of spectral data obtained with SpeX IR imager and spectrograph.***



## ***7. Spectrum Analysis***

**7.1 DIPSO.STARLINK** – a plotting package with some basic astronomical applications

**7.2 ICUR.IDL** - a generalized program to display and measure spectra

**7.3 PINTOFALE** - analyzes spectroscopic data from optically-thin coronal plasmas

**7.4 SHERPA** - a modeling and fitting application

**7.5 SPECTRUM** - a stellar spectral synthesis program

**7.6 SPECVIEW** - 1-D spectral visualization and analysis of astronomical spectrograms

**7.7 SPLAT** - displaying, comparing, modifying and analyzing astronomical spectra


**7.8 STECKMAP.GALAXIES** - a toolkit to interpret the stellar absorption features of integrated light spectra of stellar populations

**7.9 XSTAR** - a command-driven, interactive program for calculating the physical conditions and emission spectra of photoionized gases.

7.1 DIPS0.STARLINK - DIPS0 is, historically, *a simple plotting package incorporating some basic astronomical applications*. DO read the documentation fully at some time; **DIPS0 can do a lot of things, some of which you might not know that you needed** until you read about them...

7.2 ICUR.IDL - ICUR is a generalized program which permits the user to **display and measure spectra**. Written in IDL, ICUR is **a cursor-oriented spectral display and analysis program**.

7.3 PINTOFALE - originally developed to *analyze spectroscopic data from optically-thin coronal plasmas*, though **much of the software is sufficiently general to be of use in a much wider range of astrophysical data analyzes**.



**PINTofALE**

**Package for Interactive Analysis  
of Line Emission**

[Description](#) | [References](#) | [Contacts](#)  
[Download](#) | [Documentation](#) | [Acknowledgements](#)      [Last Updated: 2010](#)

## 7.4 SHERPA

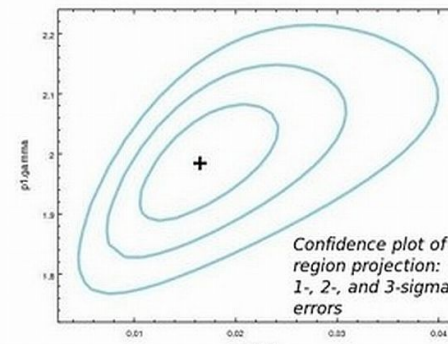
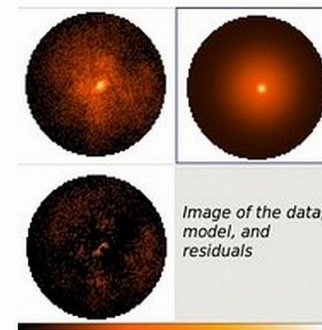
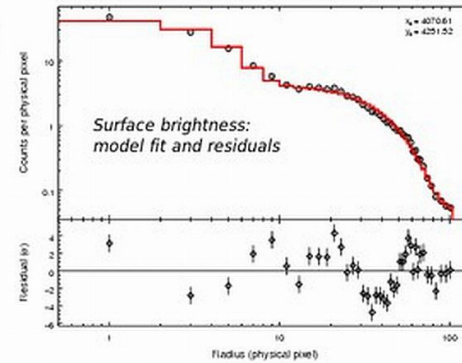


Sherpa enables the user to **construct complex models from simple definitions and fit those models to data, using a variety of statistics and optimization methods**. Sherpa lets you:

Fit 1-D data sets (simultaneously or individually), **including**: spectra, surface brightness profiles, light curves, general ASCII arrays; access the internal data arrays; build complex model expressions; import and use your own models; choose appropriate statistics for modeling Poisson or Gaussian data; import new statistics, with priors if required by analysis; visualize a parameter space with simulations or using 1-D/2-D cuts of the parameter space; calculate confidence levels on the best-fit model parameters; etc... (examples on next slide...)

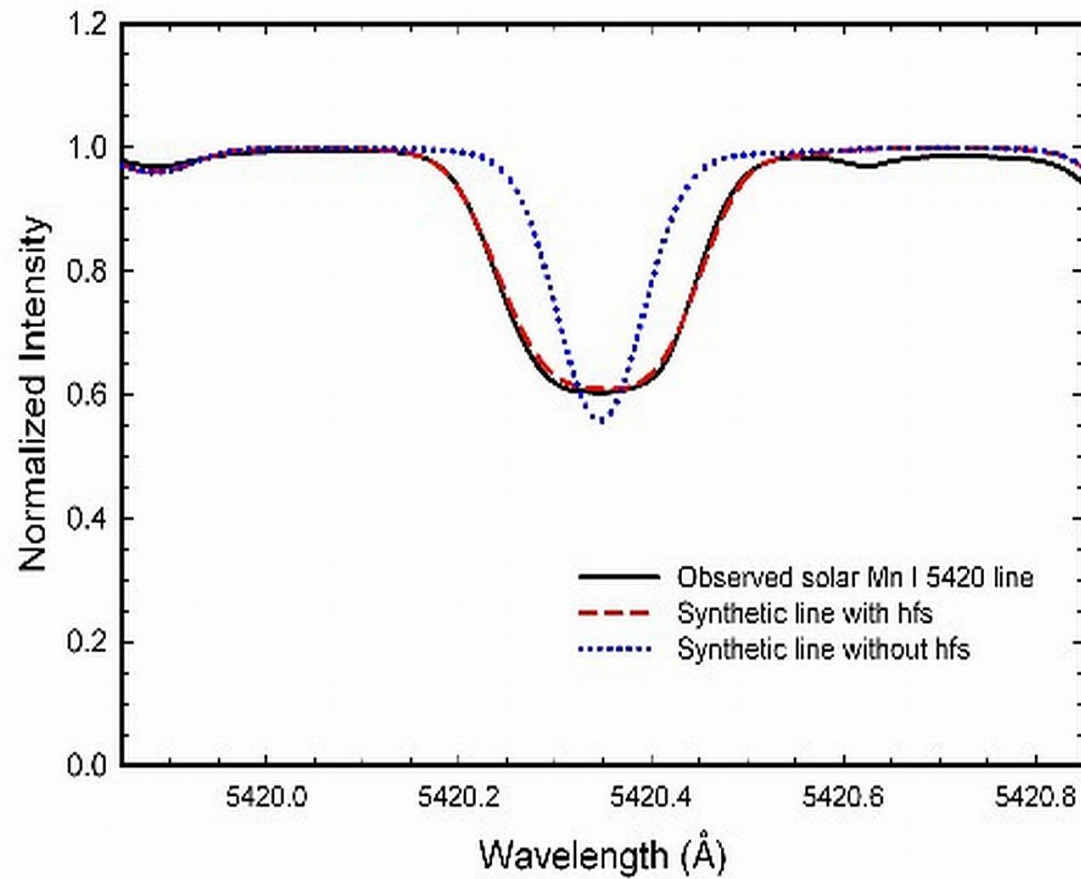
### Sherpa lets you:

- fit 1-D data sets (simultaneously or individually), including:  
spectra, surface brightness profiles, light curves, general ASCII arrays;
- fit 2-D images/surfaces in the Poisson/Gaussian regime;
- access the internal data arrays;
- build complex model expressions;
- import and use your own models;
- choose appropriate statistics for modeling Poisson or Gaussian data;
- import new statistics, with priors if required by analysis;
- visualize a parameter space with simulations or using 1-D/2-D cuts of the parameter space;
- calculate confidence levels on the best-fit model parameters;
- choose a robust optimization method for the fit: Levenberg-Marquardt, Nelder-Mead Simplex or Monte Carlo/Differential Evolution;
- and use Python to create complex analysis and modeling functions, build the batch mode analysis or extend the provided functionality to meet the required needs.



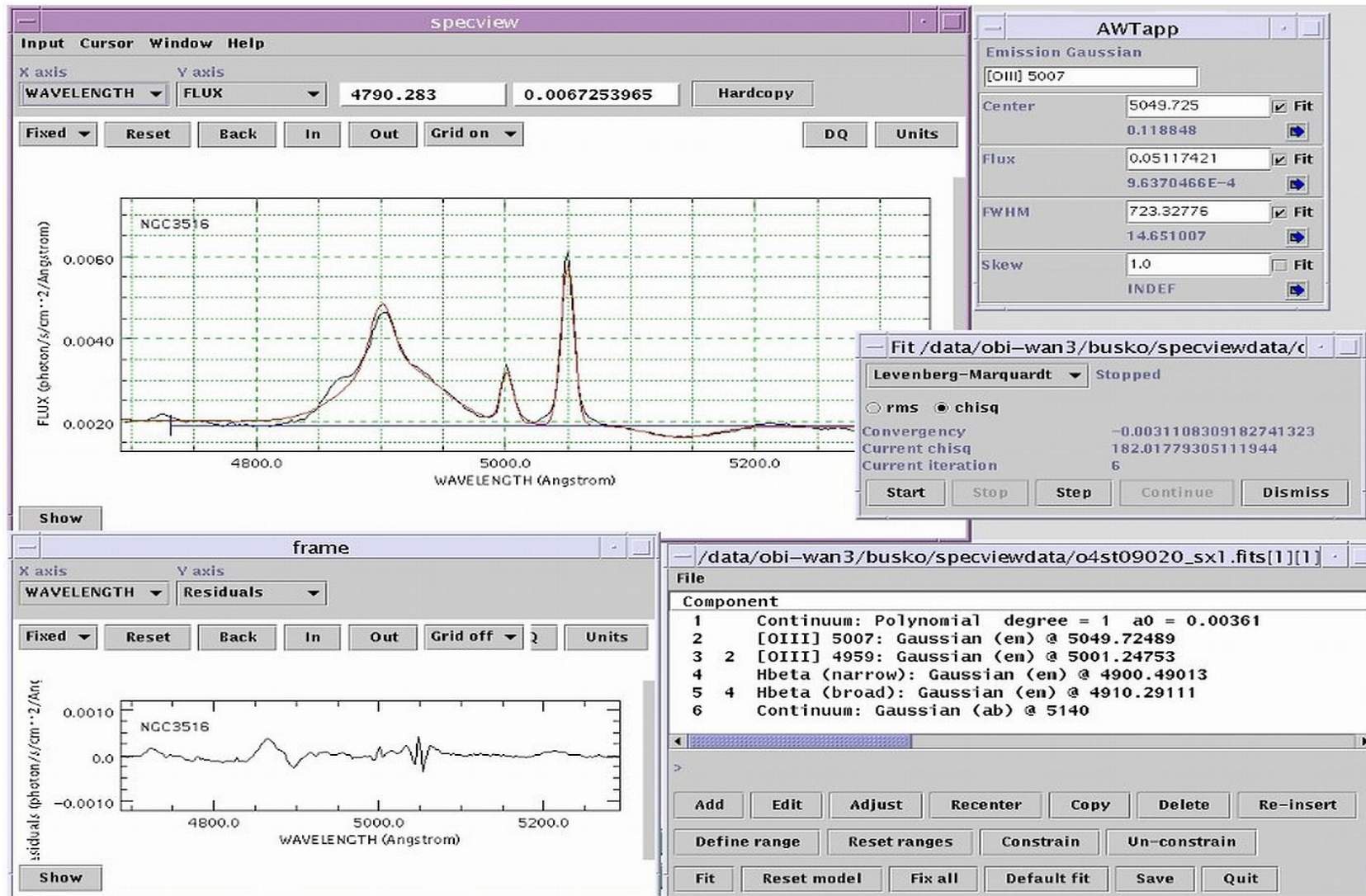
7.5 SPECTRUM - currently, *SPECTRUM* is suitable for computing stellar spectra in the spectral-type range B – mid M.

## SPECTRUM *A Stellar Spectral Synthesis Program*

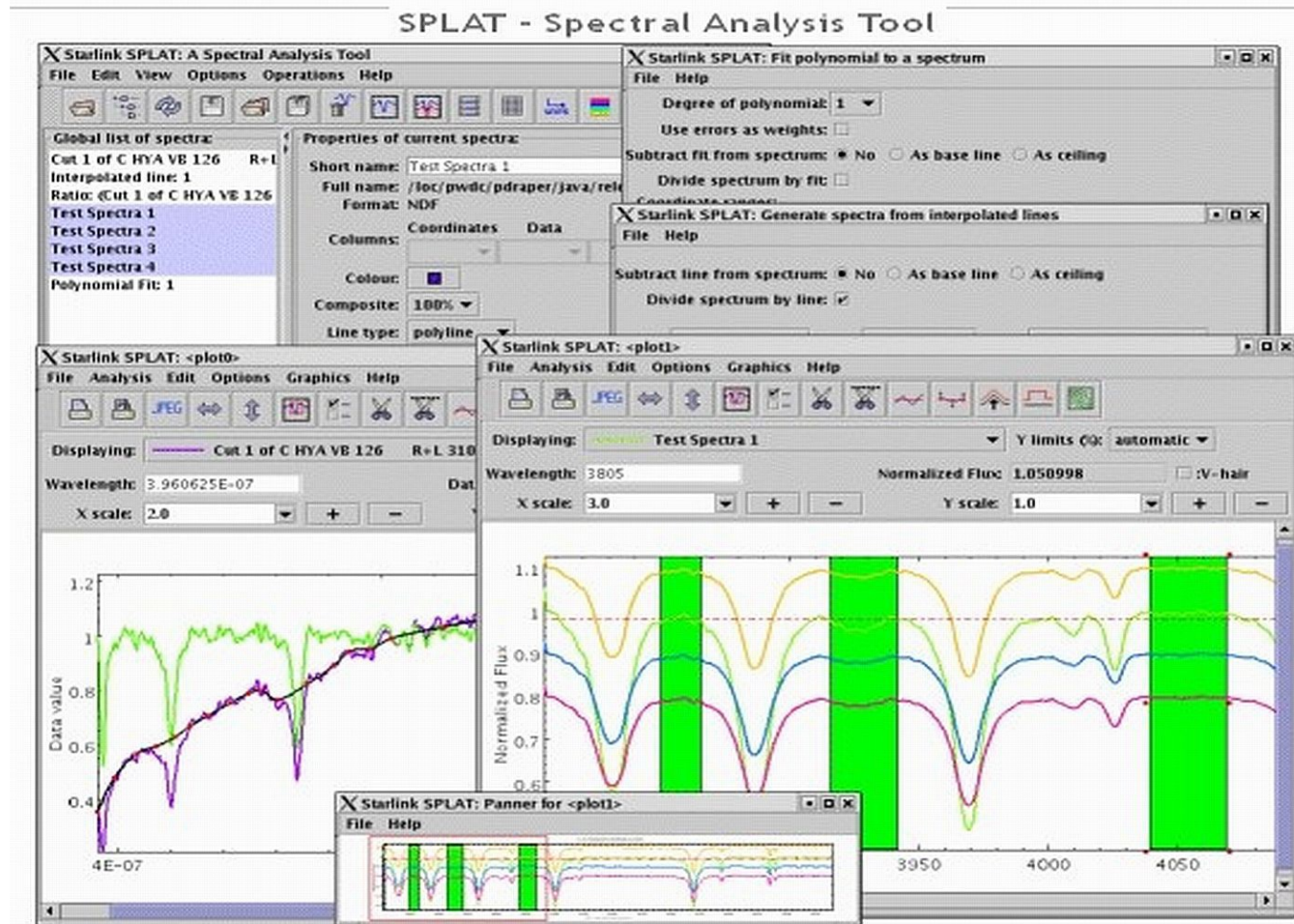




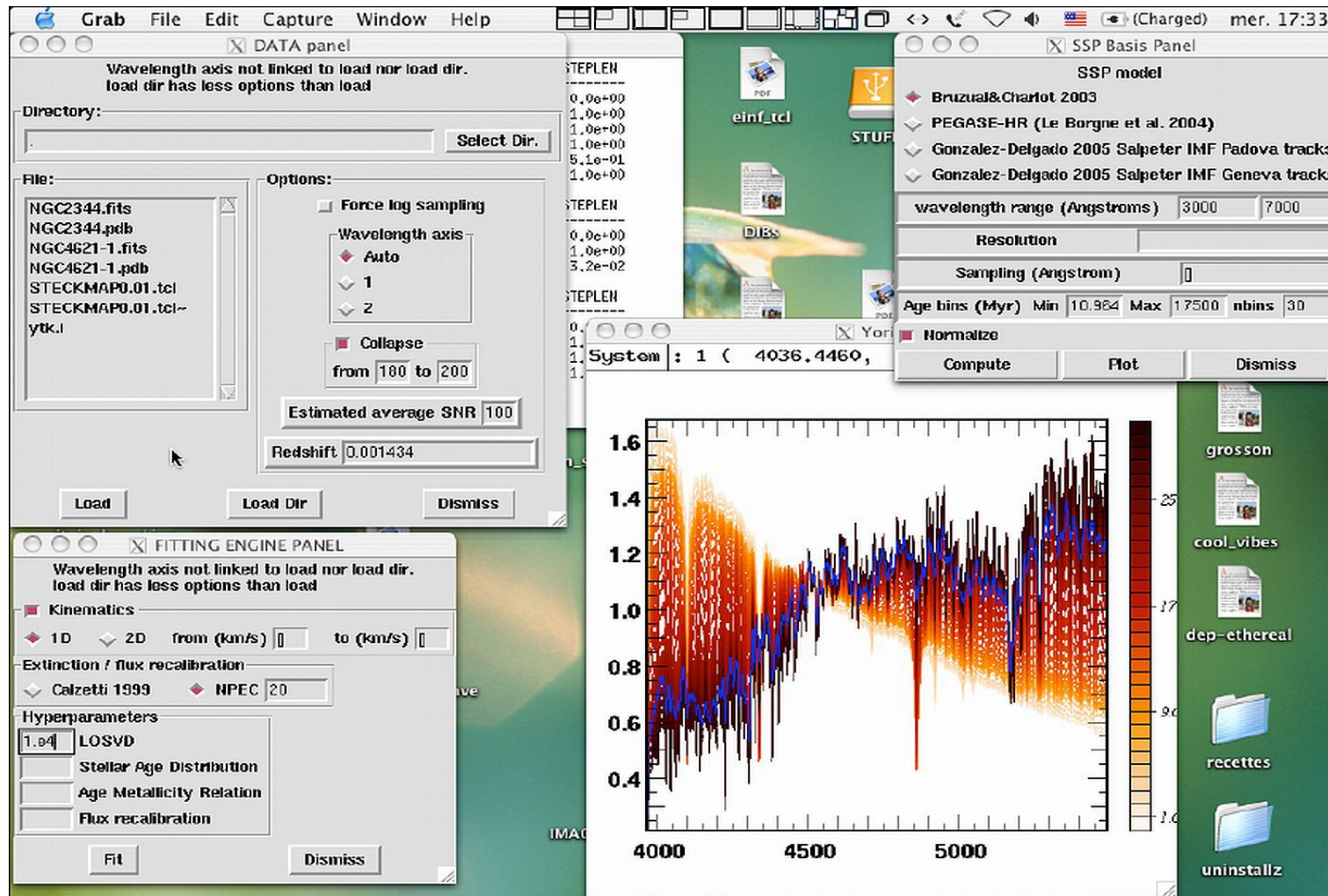
## 7.6 SPECVIEW - a tool for 1-D spectral visualization and analysis of astronomical spectrograms.



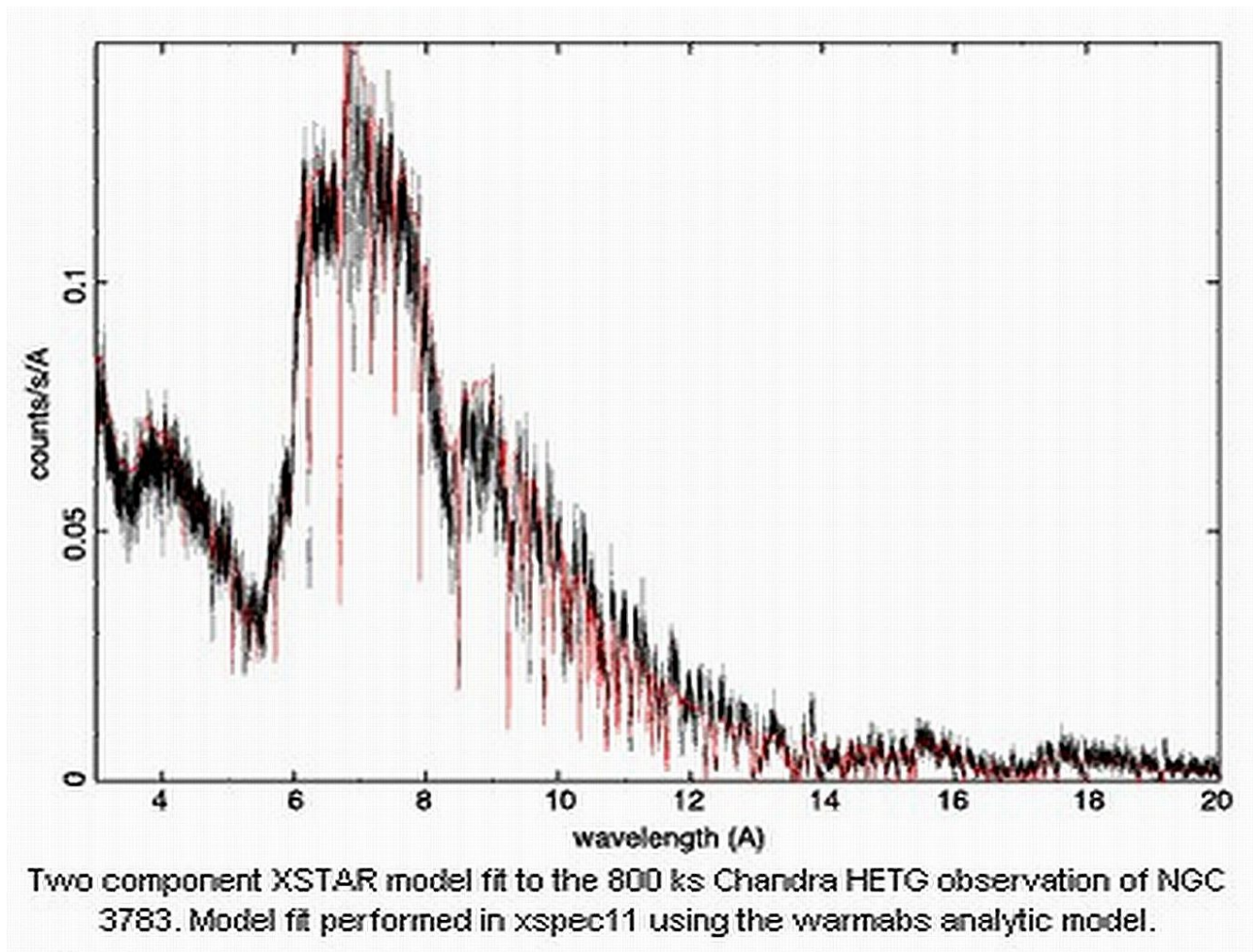
7.7 SPLAT - a graphical tool *for displaying, comparing, modifying and analyzing astronomical spectra* stored in NDF, FITS and TEXT files as well as the new NDX format.



7.8 STECKMAP - a powerful toolkit for whoever wishes to *interpret the stellar absorption features of integrated light spectra of stellar populations*. It is written in *yorick*.



7.9 XSTAR - a command-driven, interactive, computer program for *calculating the physical conditions and emission spectra of photoionized gases*.



## ***8. Visualization software***

**8.1 ALADIN** - an interactive software sky atlas

**8.2 DS9** - an astronomical imaging and data visualization application

**8.3 GAIA-ESO** - an interactive image display tool

**8.4 FUSE.IDL** – an IDL widget for displaying and manipulating FUSE data files

**8.5 FV FITS VIEWER** - a general-purpose FITS file editor

**8.6 KARMA TOOLKIT** - a package for visualization multi-dimensional images, signal and image processing applications.

**8.7 PROFIT** - a GUI tool for accessing high-resolution spectra

**8.8 QFITSVIEW** - a FITS file viewer for one, two, and three-dimensional FITS files.

**8.9 SDSS.SKYSERVER** - the data access site for the Sloan Digital Sky Survey

**8.10 SKYCAT-ESO** - a tool for visualization and astronomy archives data access

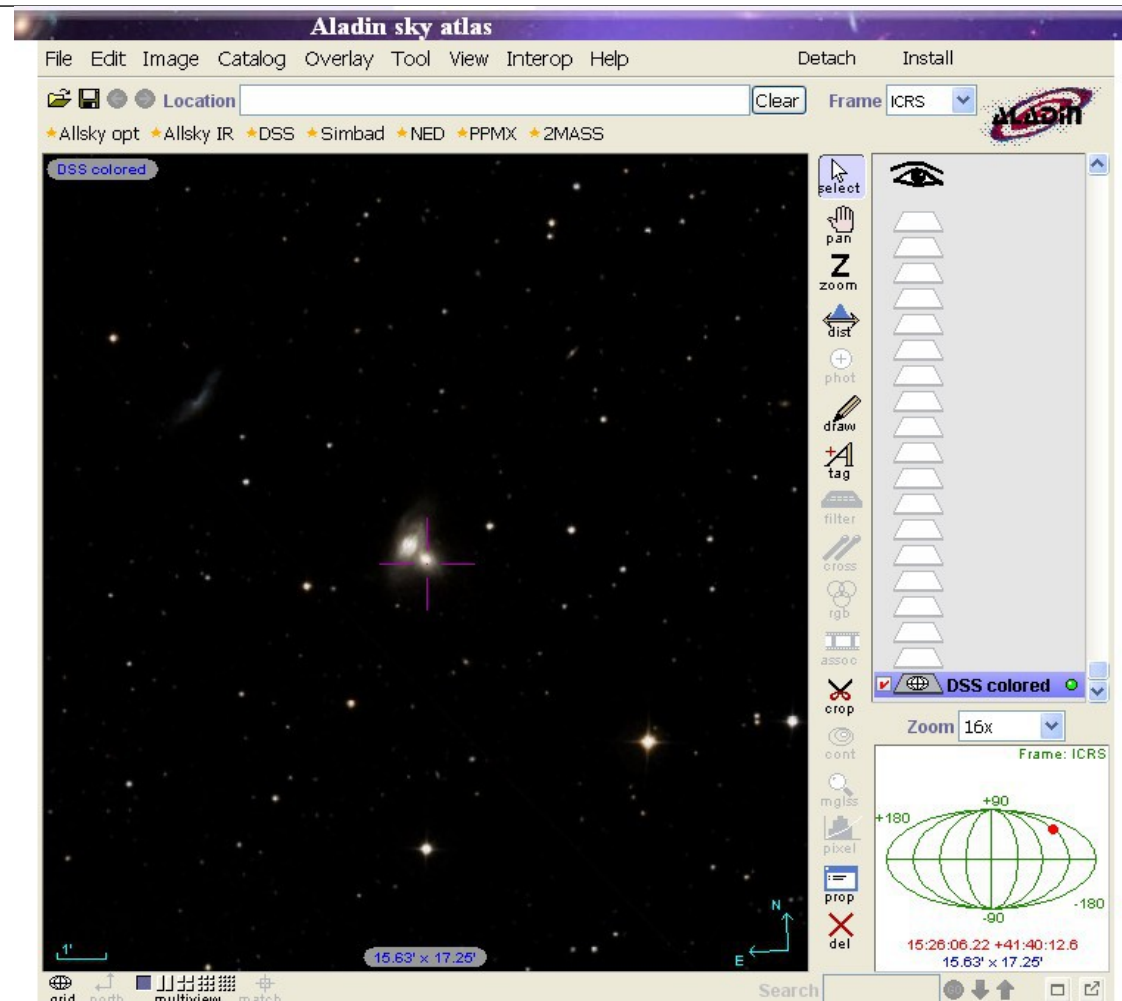
**8.11 SKYMAP** - an astronomical mapping program for creation of finder charts

**8.12 VIRGO** – a Visual Browser plug-in for the planetarium software Stellarium

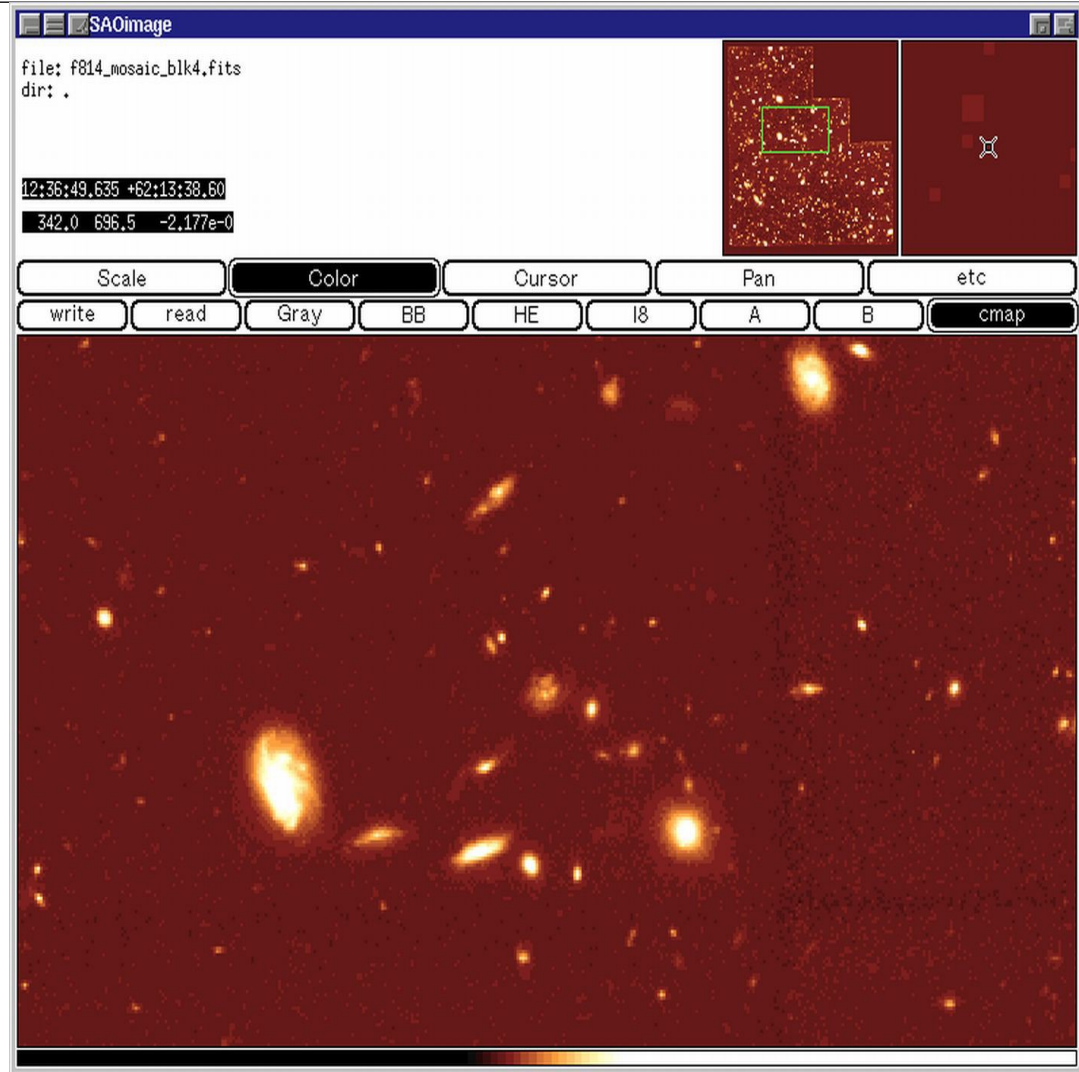
**8.13 VISIT** - a interactive parallel visualization and graphical analysis tool

## 8.1 ALADIN

An *interactive software sky atlas* allowing the user to visualize digitized astronomical images, superimpose entries from astronomical catalogues or databases, and interactively *access related data and information from the Simbad database, the VizieR service and other archives for all known sources in the field* (see available data).



**8.2 DS9 - SAOImage DS9 is an astronomical imaging and data visualization application.** DS9 supports FITS images and binary tables, multiple frame buffers, region manipulation, and many scale algorithms and colormaps. It provides for easy communication with external analysis tasks and is highly configurable and extensible via XPA and SAMP. DS9 is a stand-alone application. *It requires no installation or support files.* DS9 also supports FTP and HTTP access.



### 8.3 GAIA-ESO (now via StarLink...)

GAIA - Graphical Astronomy and Image Analysis Tool

---



**8.4 FUSE.IDL - IDL widget *programs for displaying and manipulating FUSE data files***, written by Don Lindler. There are many features in this program for manipulating time-tag data. The following programs for the reading and display of FUSE images and spectra have been contributed at JHU (Alex Fullerton, Don Lindler, Ed Murphy, Bill Oegerle, Dave Sahnou): **ftv.pro; readit.pro; plotrate.pro; showdetector.pro; allsegments.pro; hist\_combine .**



## 8.5 FV FITS VIEWER

### *Fv*: The Interactive FITS File Editor

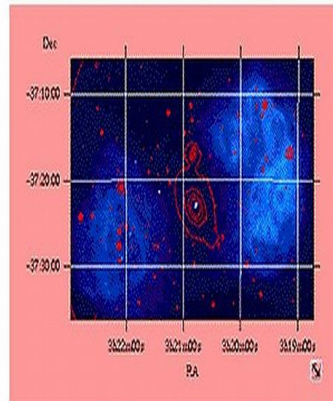
The latest version is 5.3, released July 2009

*Fv* is the easy to use graphical program for viewing and editing any FITS format image or table. The *Fv* software is small, completely self-contained and ready to run on

- Windows PCs
- Most Unix platforms
- Mac OS-X

*Fv* can be used with the [DS9](#) image display.

[Download \*Fv\* now...](#)



*Images and Contours*

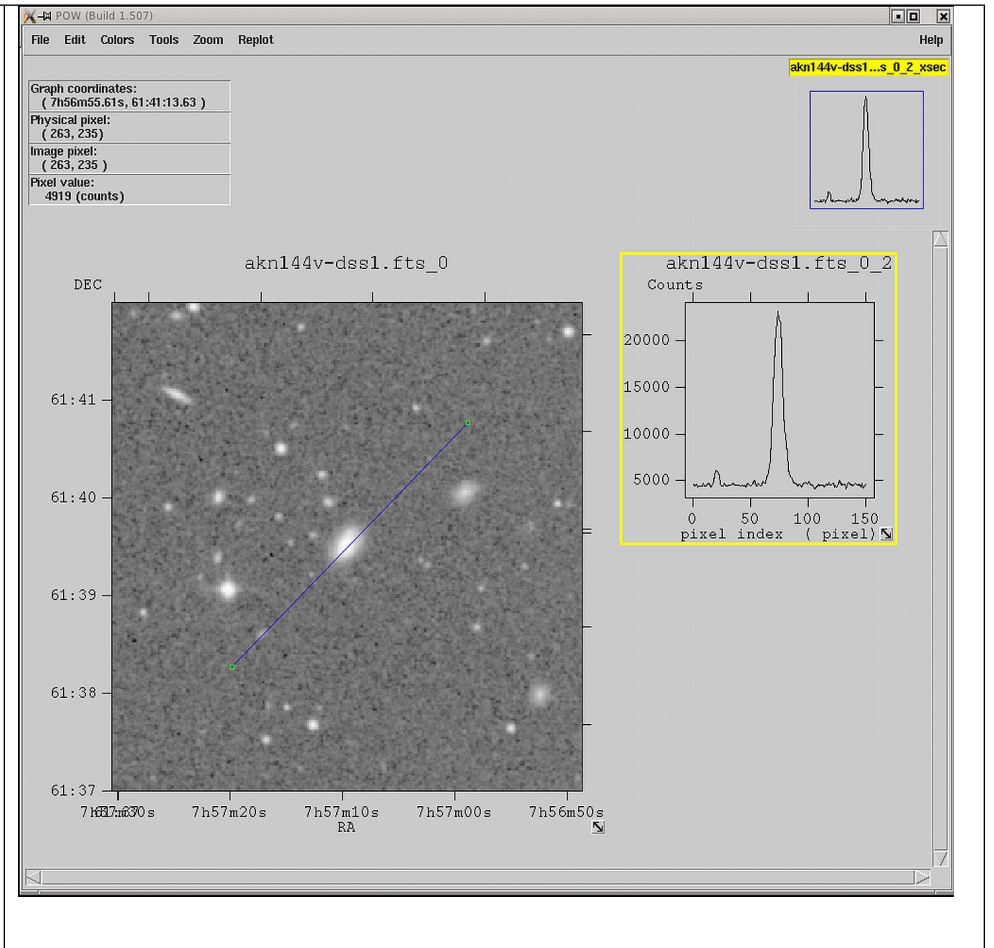
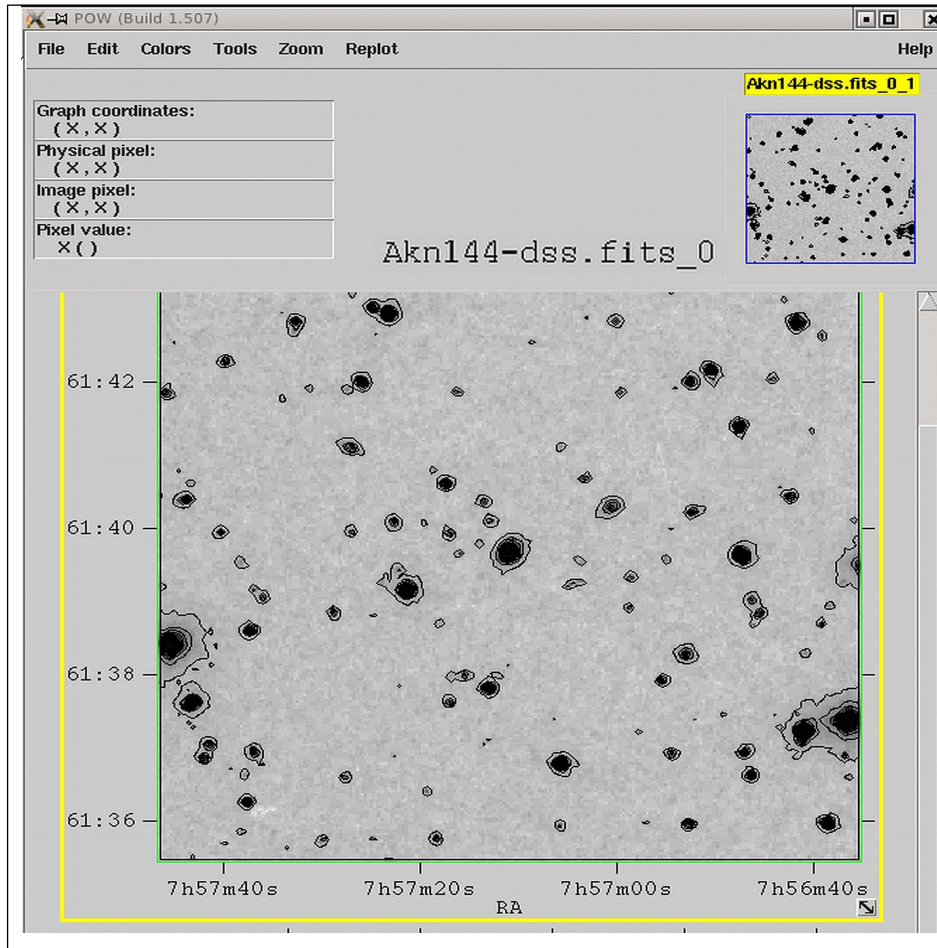
# *FITSview*

The FITSview family consists of viewers for astronomical images in FITS format. Viewers are available for MS-Windows, Macintosh and Unix systems and offer a wide variety of [image display features](#). The FITSview programs are distributed free of charge by the (USA) National Radio Astronomy Observatory. These programs are Y2K compliant.

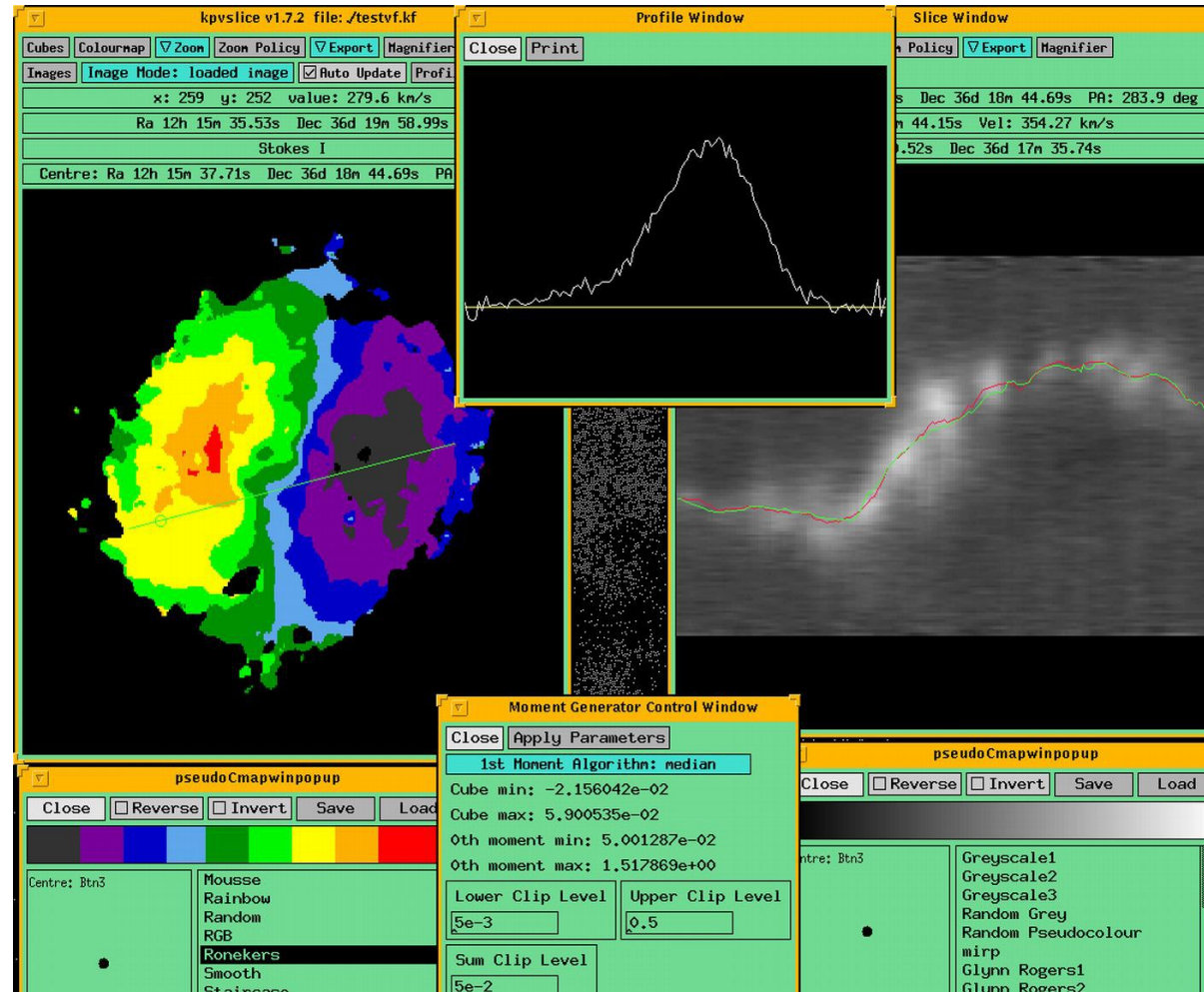
***FITSview***  
for Windows

***FITSview***  
for Macintosh

***FITSview***  
for Unix

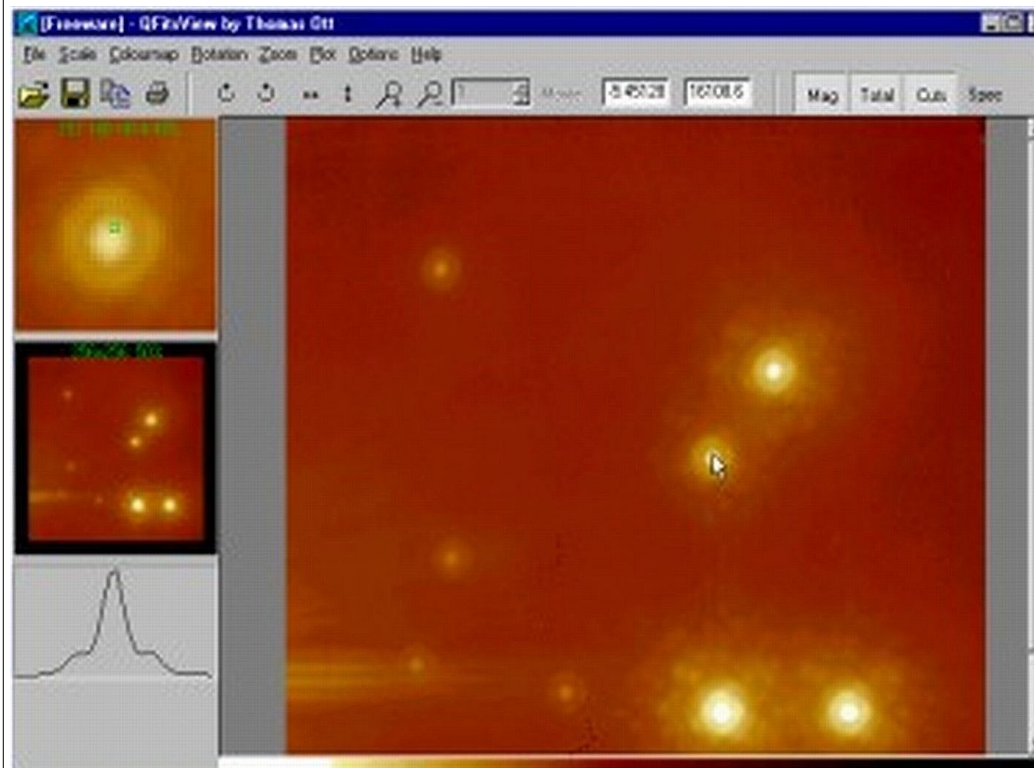


## 8.6 KARMA TOOLKIT - *A package for visualization multi-dimensional images, signal and image processing applications.*



**8.7 PROFIT** - a GUI (graphical user interface) *tool for accessing high-resolution spectra*. Profit displays spectra in various formats, allowing users to identify emission lines, to convert an identified line into velocity units using a user-selected wavelength, to store (and restore) individual spectra, to fit lines to gaussians, and other features.

## 8.8 QFITSVIEW



**8.9 SDSS.SKYSERVER** - the **data access site for the Sloan Digital Sky Survey**. From the sites, you can view all of the SDSS data, using the same tools that professional astronomers use.

**Sloan Digital Sky Survey / SkyServer**

SDSS DR7 JHU Mirror

Home Tools Schema Projects Astronomy SDSS Contact Us Download Site Search Help

Welcome to the **DR7 DR7 JHU Mirror site!!!**

This website presents data from the Sloan Digital Sky Survey, a project to make a map of a large part of the universe. We would like to show you the beauty of the universe, and share with you our excitement as we build the largest map in the history of the world.

**News**  
The site hosts data from **Data Release 7 (DR7)**. **What's new in DR7, what's new on this site, and known problems.** [More...](#)

**For Astronomers**  
A separate branch of this website for professional astronomers (English) [More...](#)

SDSS is supported by

SDSS NSF NASA MEXT

Powered by **Microsoft**

Site Traffic Privacy Policy

**SkyServer Tools**  
Famous places  
Get images  
Visual Tools  
Explore  
Search  
Object Cross-ID  
CasJobs

**Science Projects**  
Basic  
Advanced  
Challenges  
For Kids  
Games and Contests  
Teachers  
Links to other projects

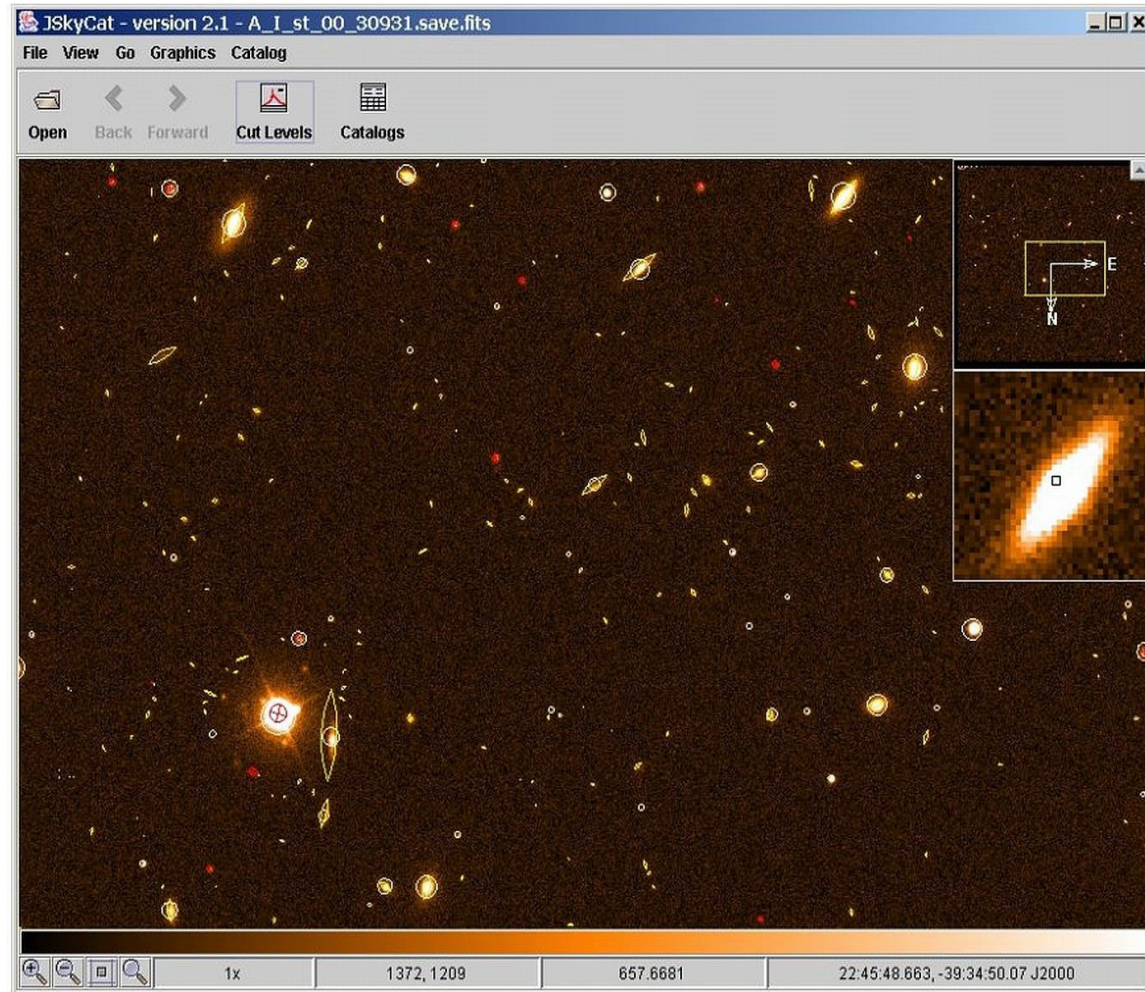
**Info Links**  
About Astronomy  
About the SDSS  
About the SkyServer  
SDSS Data Release 7  
SDSS Project Website  
Open SkyQuery  
Images of RC3 Galaxies

**Help**  
Getting Started  
FAQ  
How To  
Glossary  
Schema Browser  
Sample SQL Queries  
Details of SDSS Data

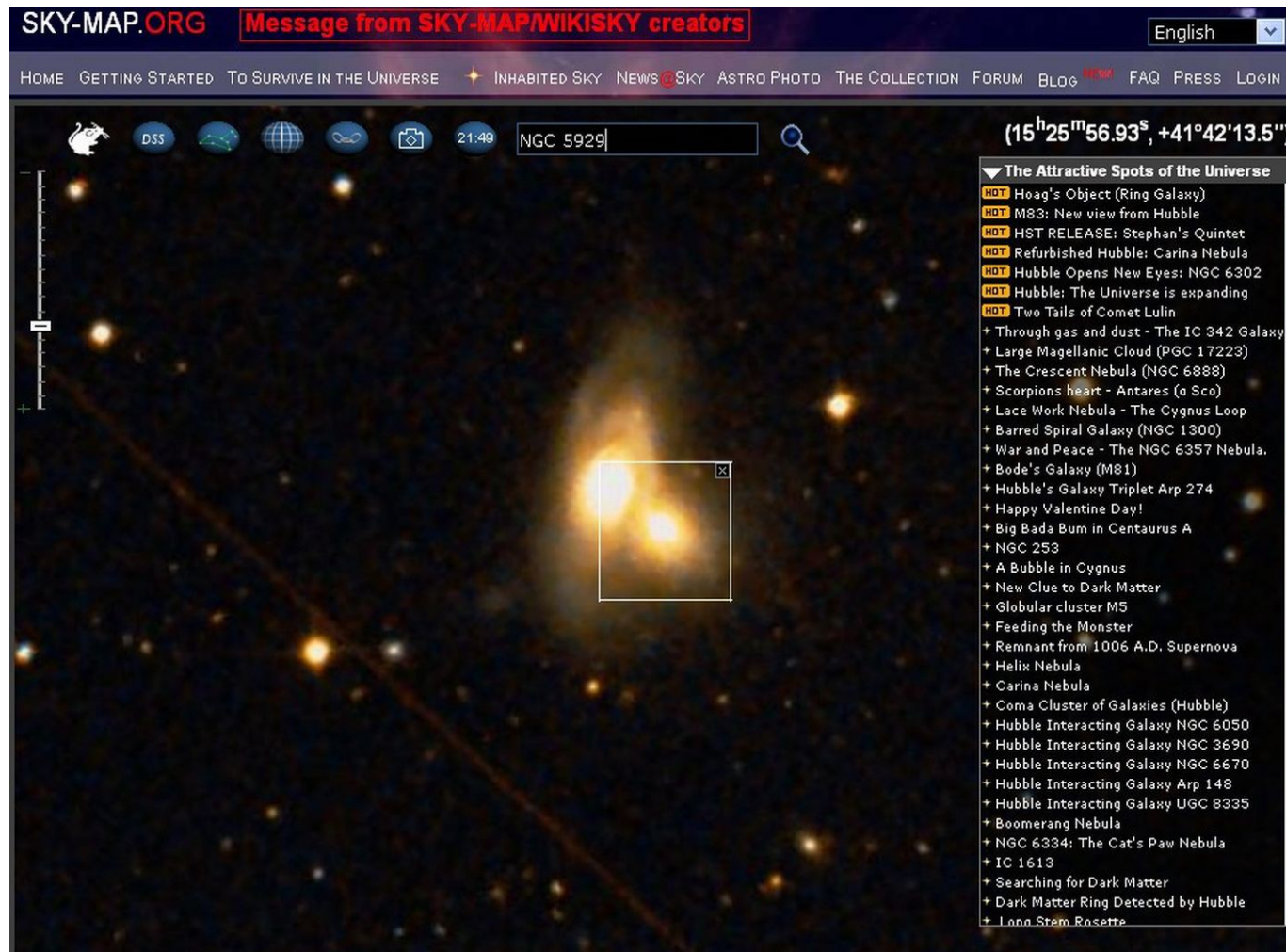
The contours for boundaries of the six different regions

Region	Color	South	Lat	East	West
1	Blue	0	0	0	0
2	Green	0	0	0	0
3	Red	0	0	0	0
4	Yellow	0	0	0	0
5	Purple	0	0	0	0
6	White	0	0	0	0

8.10 SKYCAT-ESO - a tool that *combines visualization of images and access to catalogs and archive data* for astronomy. Below is Java SkyCat application



**8.11 SKYMAP** - an *astronomical mapping program* written in Fortran and C for Unix workstations by Doug Mink of the Smithsonian Astrophysical Observatory Telescope Data Center.



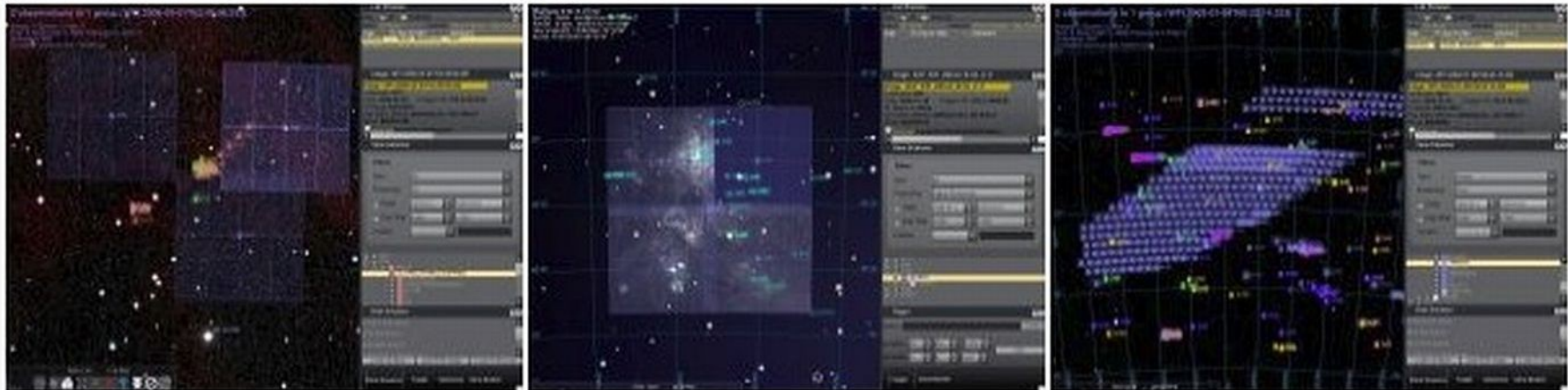
## 8.12 VIRGO



VirGO is the next generation Visual Browser for the ESO Science Archive Facility developed by the VO Systems Department. It is a plug-in for the popular open source software [Stellarium](#) with added capabilities for browsing professional astronomical data. VirGO gives astronomers the possibility to easily discover and select data from millions of observations in a new visual and intuitive way. Its main feature is to perform real-time access and graphical display of a large number of observations by showing instrumental footprints and image previews, and to allow their selection and filtering for subsequent retrieval. It reads FITS images and catalogues in VOTable format. It superimposes DSS background images and allows to view the sky in a *real life* mode as seen from the main ESO sites.

Data interfaces are based on Virtual Observatory [standards](#) enabling access to images and spectra hosted by other data centers and to exchange data with other VO applications through the [PLASTIC](#) messaging system.

These screenshots illustrate some of the main features of VirGO such as footprints, DSS background, previews or browsing through large number of data sets.





8.13 *VISIT - an interactive parallel visualization and graphical analysis tool for viewing scientific data.* Users can quickly generate visualizations from their data, animate them through time, manipulate them, and save the resulting images for presentations. VisIt contains a rich set of visualization features so that you can view your data in a variety of ways. It can be used to visualize scalar and vector fields defined on two- and three-dimensional (2D and 3D) structured and unstructured meshes. VisIt was designed to handle very large data set sizes in the terascale range and yet can also handle small data sets in the kilobyte range. VisIt handles 2D and 3D data equally well. VisIt also has the ability to animate data, allowing users to see the time evolution of their data. VisIt is also a powerful analysis tool. It provides support for derived fields, which allow new fields to be calculated using existing fields.

## **9. VO software** - details presented during the VII\_SBAC

**9.1 ESO-MEX** - tools for publishing images and spectra

**9.2 SAADA** - transforms a set of heterogeneous FITS files or VOTables of various categories (images, tables, spectra....) into a database.

**9.3 DAL ToolKit**

**9.4 DATASCOPE** - searches everything for a given target or region of the sky.

**9.5 MAKI** - investigates instrument Fields of View (FOV's), and viewing multi-mission observing windows.

**9.6 PLASTIC** - a protocol for communication between client-side astronomy applications.

**9.7 SKYVIEW** - generating all sky images from Radio to Gamma-Ray

**9.8 SPECVIEW** - a tool for 1-D spectral visualization and analysis of astronomical spectrograms.

**9.9 SPLAT** - a toolbox for querying, downloading and displaying spectra from the current generation of SSAP servers.

**9.10 STILTS** - a set of command-line tools processing astronomical tables.

**9.11 TOPCAT** - an interactive graphical viewer and editor for tabular data

**9.12 VisIVO** - a visualization and analysis software for astrophysical data

**9.13 VOCONVERT** - a tool for converting files from one format to another

**9.14 VODESKTOP** – a core application with several interlinked tools

**9.15 VOEVENT** - a standardized language used to report observations of astronomical events

**9.16 VOPILOT** - a tool for visualizing astronomical data.

**9.17 VOSA** - a tool designed to perform the many tasks in an automatic manner

**9.18 VOSPEC** - a multi-wavelength spectral analysis tool with access to spectra, theoretical models and atomic and molecular line databases registered in the VO.

**9.19 VOSTAT** - statistical routines on large datasets.

## ***10. X\_ray analysis software***

**10.1 CIAO** - Chandra Interactive Analysis of Observations - useful for analysis of data not only from X-ray missions

**10.2 ISIS.XRAY** - a complete package to process CCD images using the image Optimal subtraction method

**10.3 PIMMS** – a Multi-Mission Simulator software for high-energy astrophysicists

**10.4 SAS** - a collection of tasks, scripts and libraries, specifically designed to reduce and analyze data collected by the XMM-Newton observatory

**10.5 SPEX** - a software package optimized for the analysis and interpretation of high-resolution cosmic X-ray spectra

**10.6 XSPEC** - a command-driven, interactive X-Ray Spectral Fitting Package.

**10.1 CIAO** - **C**handra **I**nteractive **A**nalysis of **O**bservations. The remarkable science capabilities of the Chandra X-ray Observatory demanded new, *flexible, multi-dimensional software to analyze the data* it returned. **A system has been proven itself useful for the analysis of data from other, non-X-ray missions**, because of the mission independence that is the basis of the CIAO design.

**10.2 ISIS.XRAY** - **a complete package to process CCD images using the image optimal subtraction method** (Alard & Lupton 1998, Alard 1999). The ISIS package can find the best kernel solution even in case of kernel variations as a function of position in the image. (**...see 1.5 too...**).

**10.3 PIMMS** - **P**ortable, **I**nteractive **M**ulti-**M**ission **S**imulator software *for high-energy astrophysicists*.

**10.4 SAS** - The **S**cience **A**nalysis **S**ystem is **a collection of tasks, scripts and libraries, specifically designed to reduce and analyze data collected by the XMM-Newton observatory**. XMM-Newton

data are available in two formats: 1) Observation Data Files (ODF), i.e. reformatted telemetry in FITS format and 2) Pipeline Processing System (PPS) products, a collection of validated, top-level scientific products

**10.5 SPEX** - a software package *optimized for the analysis and interpretation of high-resolution cosmic X-ray spectra*. The software is especially suited for fitting spectra obtained by current X-ray observatories like XMM-Newton, Chandra, and Suzaku.

**10.6 XSPEC** - An *X-Ray Spectral Fitting Package*. XSPEC is a command-driven, interactive, X-ray spectral-fitting program, completely detector-independent. XSPEC has been used to analyze data from HEAO-1 A2, *Einstein Observatory*, EXOSAT, Ginga, ROSAT, BBXRT, ASCA, CGRO, IUE, RXTE, Chandra, XMM-Newton, Integral/SPI, Swift and Suzaku.

***Thank You!***