

AstroGrid (described by Walton in *A&G* 2005 46 3.23) is the UK's Virtual Observatory (VO) Service. After an initial release in April 2005, the summer 2006 release (2006.4) offers several powerful capabilities, helping the astronomer find, get and work with a wide range of astrophysical data. Early science use of AstroGrid is being presented at the 2006 IAU General Assembly meeting, in the special session "The virtual observatory in action (SPS3)" (17–22 August 2006) and on the AstroGrid stand in the exhibition.

With AstroGrid you can:

- Find data and applications by searching the "registry" (a kind of "astro-google").
- Use AstroScope – a powerful tool for finding data over a region of the night sky, be they images, spectra or catalogues. You enter a target name or search box, the system then automatically discovers which archives might have the data you need, sends the queries to those archives, and graphically displays the results. You can then explore the results and by simple point-and-click can either visualize individual data sets, or save any number of the data to your local disc or your "MySpace".
- Use the Application Launcher – this gives a common interface to a wide range of well known astronomical applications. And you can work on data held in your MySpace.
- Use the Query Builder to send database queries to a wide range of databases, using one interface, one query language (based on standard SQL), and get results returned into a standard file format – VOTable.
- Use the Workflow Builder to create simple or powerful sequences of tasks to find and process data. A range of examples and help sheets are available to guide the novice user.
- Use a prepackaged Parameterised Workflow to carry out common processes, including: the Redshift Maker, to create your own object catalogues from multicolour image data (SExtractor), generate a federated source list (XMatch), and generate the statistical photometric redshifts for these objects (HyperZ, Bpz); the Colour Cutter, which takes a colour criteria (e.g. $H-K > 3$, $g-r < 2$) and returns the objects meeting those criteria from a range of optical and IR catalogues (e.g. ING Wide Field Survey, 2MASS); and the movie maker, where you enter a start and end time, and generate a movie of the Sun (from either TRACE or SOHO-EIT) data.
- Visualize your data with TopCat, Aladin or other powerful applications designed to exploit fully data provided in standard VO formats.

AstroGrid science and tools

The capabilities available through the AstroGrid system have been developed to meet the specific needs of the UK astronomy community. Several key science topics have been identified, with science cases from these acting as test cases for the



1: The AstroGrid workbench, which provides access to the full range of AstroGrid science services.

AstroGrid: A place for your science

Nicholas A Walton, Silvia Dalla, Eduardo Gonzalez-Solarez, Anita Richards and Jonathan Tedds show off the fast-developing astronomical applications of the UK's virtual observatory service.

ABSTRACT

AstroGrid has moved a few steps closer to the ideal virtual observatory and the latest release provides easy access to a range of international data sources and relevant astrophysical tools. Here we demonstrate the capabilities of this single interface for a variety of astrophysical applications.

use of the developing AstroGrid system. Further, the AstroGrid science themes create a framework in which user-defined science cases can be developed, building upon the science services and data/tool access capabilities present in the system. Specific cases falling within a theme in turn create the drivers for new or expanded capability.

AstroGrid's main science themes are:

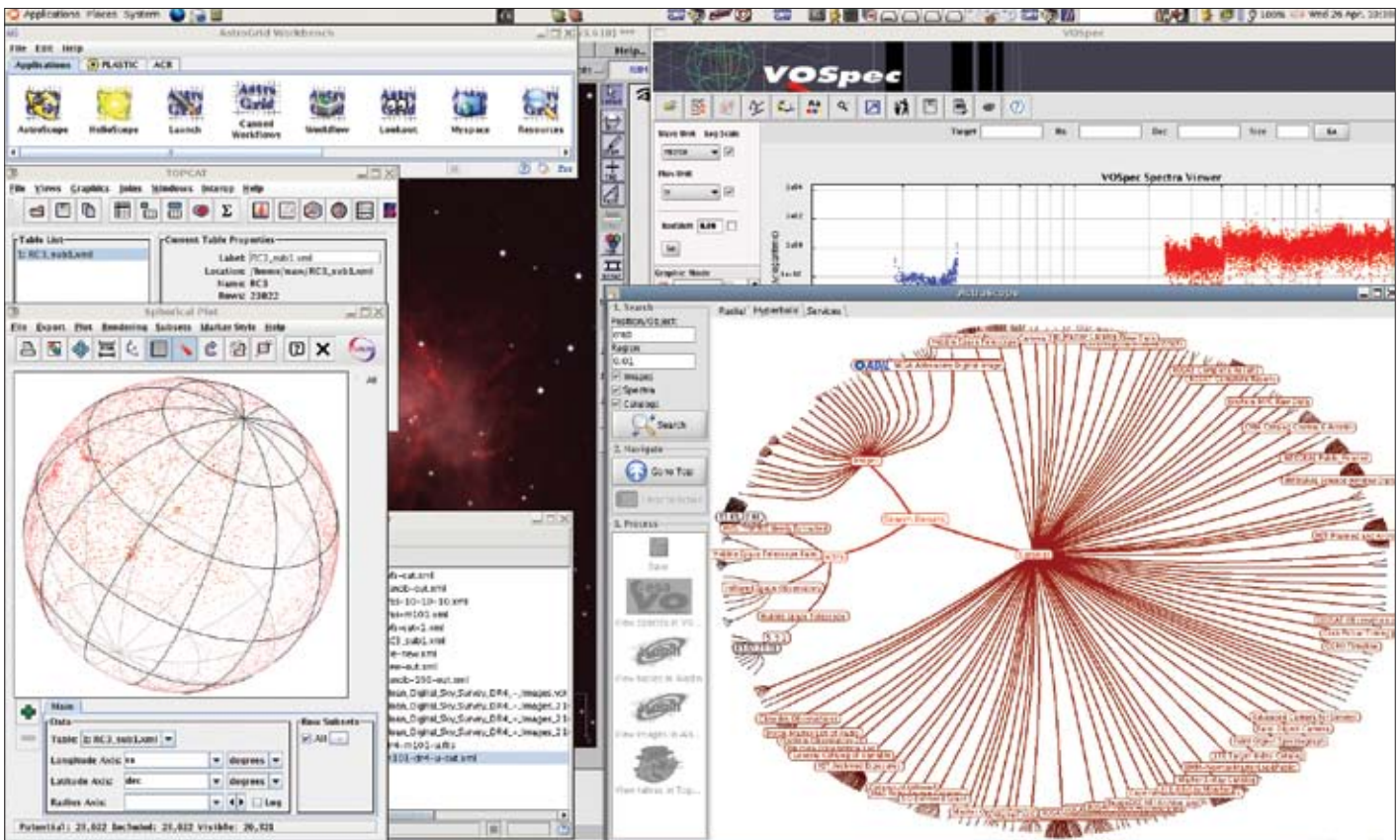
- Multi- λ imaging. This science case builds on the study of deep or large fields, with the science aim, for example, of understanding the properties of galaxy evolution as a function of distance, observed by different facilities at different wavelengths. The Redshift Maker is one of the science services developed as part of this theme. An additional science case is the study of clusters from deep near-infrared and optical data.
- Stellar populations, which builds on the selection of brown dwarf candidates using the Colour Cutter. Additional science cases include the study of Gould Belt objects and of the IMF in clusters.
- Morphologies and, in particular, study of low surface brightness galaxies and HII, SNR, PN, in H α surveys.
- Extreme objects and, in particular, the environments within which supernova and gamma-ray bursts originate.
- Sun–Earth connection, building on the solar/solar–terrestrial physics science cases for which the SolarMovieMaker has been developed.

Here we present a case study, in which an astronomer is interested in finding local brown

dwarfs or young massive stars. Cool or young obscured stars have distinctive spectral energy distributions of 0.5–2 μm wavelength, because they are brighter in the near infrared than at optical wavelengths. Radio and X-ray measurements distinguish between low- and high-mass young stars. UV emission allows a more detailed spectral classification of hot stars.

Using AstroGrid, a single query through AstroScope can provide deep optical and NIR catalogues and images from the Isaac Newton Group's Wide Field Survey, the IR and radio catalogues IRAS, 2MASS, FIRST, any known X-ray detections in 1XMM (and now 2XMM beta) and UV spectra from the ESA INES archive. The researcher doesn't need to know where the data are or who is providing the information; they just have to select a source or position of interest and AstroGrid can deliver a huge range of data to the desktop, or make it available to other, equally convenient, processing tools.

Data for this particular case is easy to find and accessible from a range of data providers. AstroGrid consortium data centres, including CASU (Cambridge), which includes deep optical images and source catalogues from the Isaac Newton Telescope Wide Field Survey, IPHAS H α survey images (<http://www.ipas.org>), selected Spitzer survey images such as the ELAIS region, HST ACS Ultra Deep Field images and the Faint Images of the Radio Sky at Twenty-one cm catalogue; LEDAS (Leicester) has 1XMM X-ray



2: This figure shows how a user can search for data resources available for the Crab nebula utilizing AstroScope where a number of relevant resources have been automatically visualized in the appropriate tool, such as Aladin for images, Topcat for tabular data and VOSpec for spectra. One can also see data that had been saved to the user's MySpace. All applications are launched from the AstroGrid workbench, seen in the top left of the image.

source catalogue and Sloan Digital Sky Survey images and ROE (Edinburgh) holds the 6dF optical survey and cross-identifications, 2MASS all-sky IR survey, USNO-B astrometric catalogue and SuperCosmos surveys. Many international data centres are made available through the AstroGrid registry. Standard VO access methods connect to data centres and resources such as, in the USA, NED (The NASA/IPAC Extragalactic Database), HEASARC (high energy and many other catalogues), STScI, IRSA and MAST (NASA and other mission catalogues and images including HST and Spitzer), as well as Sloan Digital Sky Survey images and catalogues. Spain offers ESA archives (ISO and XMM data), Canada, CADC (Gemini and other data), and from Japan there is the Japanese Virtual Observatory, with Subaru/XMM survey data (IR/X-ray).

New data are coming all the time. X-ray data from all the major missions hosted at LEDAS (Leicester) will soon be available, followed by images and spectra such as UVES from the European Southern Observatory archive in Munich and expanded access to Vizier (Strasbourg). Next-generation surveys and telescopes including UKIDSS, VISTA, e-MERLIN and ALMA are already planning to make their data available.

Visualization

A range of helper applications allow for quick visualization of data uncovered through AstroScope, or results saved in your MySpace. For example,

VOSpec allows you to visualize spectra found via AstroScope. The "Plastic" protocol allows passing of information between client applications across the AstroGrid service layer. Thus one could select several data points in one application, and see those same points in another. For example, you could select extremely red objects found in tabular data visualized by Topcat, and see images of those objects through Aladin.

Using AstroGrid, you can also save data in your personal "MySpace" area. Tabular data are usually in VOTable format, for cross matching, sending to a photometric redshift tool and so on, or exporting as plain text to your desktop. Large FITS images may be made available via a VOTable containing basic parameters and a pointer to the data which can be downloaded or passed on to source extraction or other tools.

AstroGrid is built conforming to global standards agreed by the International Virtual Observatory Alliance (<http://www.ivoa.net>). This guarantees that users of AstroGrid will be able to access data and applications provided by global data centres, and be able to run science work flows incorporating those data sets.

AstroGrid provides services to a broad range of end users. For the solar and solar-terrestrial physics community, it provides a single infrastructure for access to solar system data sets and applications. The HelioScope application gives users easy access to heliospheric datasets, breaking traditional boundaries between different

areas of solar system research. The Solar Movie Maker Science Service provides an easy-to-use tool for generating movies of solar images. The AstroGrid workflow is a programming environment where users can develop their own science workflows, combining information from multiple datasets and catalogues. Finally, AstroGrid provides bridging between data and models, as demonstrated by work on the Coupled Thermosphere Ionosphere Plasmasphere (CTIP) model.

The HelioScope application allows users to retrieve data for a time range of interest, from various providers including solar image archives, time-series repositories and catalogues. In its initial version, HelioScope queries the Virtual Solar Observatory and the NASA Coordinated Data Analysis Web system, and returns information on available files for the requested time range. The user can visualize this information and select data for download. HelioScope is modelled on the AstroScope service developed by AstroGrid for night-time astronomy archives.

Use AstroGrid now

AstroGrid is ready to try out and to use – just go to <http://www.astrogrid.org/launch> to find out how. Without registration you'll be able to use AstroScope to discover and locally visualize data. With a simple registration procedure you'll gain access to the full features of the AstroGrid Workbench – including being able to save data and results to your MySpace virtual storage.

Key links for AstroGrid

AstroGrid <http://www.astrogrid.org>

Use AstroGrid

<http://www.astrogrid.org/launch>

AstroGrid science

<http://science.astrogrid.org/>

AstroGrid software

<http://software.astrogrid.org/>

Euro-VO <http://www.euro-vo.org>

Euro-VO Technology Centre

<http://www.eurovotech.org>

IVOA <http://www.ivoa.net>

Aladin <http://aladin.u-strasbg.fr/>

TopCat

<http://www.star.bris.ac.uk/~mbt/topcat>

VOSpec <http://esavo.esa.int/vospec/>

AstroGrid contacts

Project Leader

Andrew Lawrence al@roe.ac.uk

Project Manager

Keith Noddle ktn@star.le.ac.uk

Project Scientist

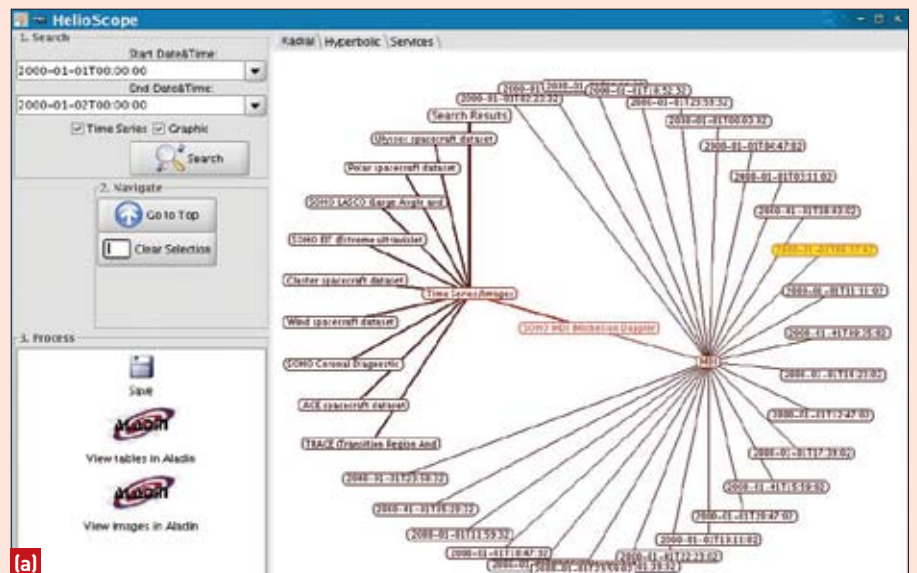
Nicholas Walton naw@ast.cam.ac.uk

AstroGrid is building a flexible framework for the creation of a Virtual Observatory. With European partners, through its participation in the Euro-VO it provides the infrastructure for the Euro-VO, upon which partners can easily add specialized data and applications.

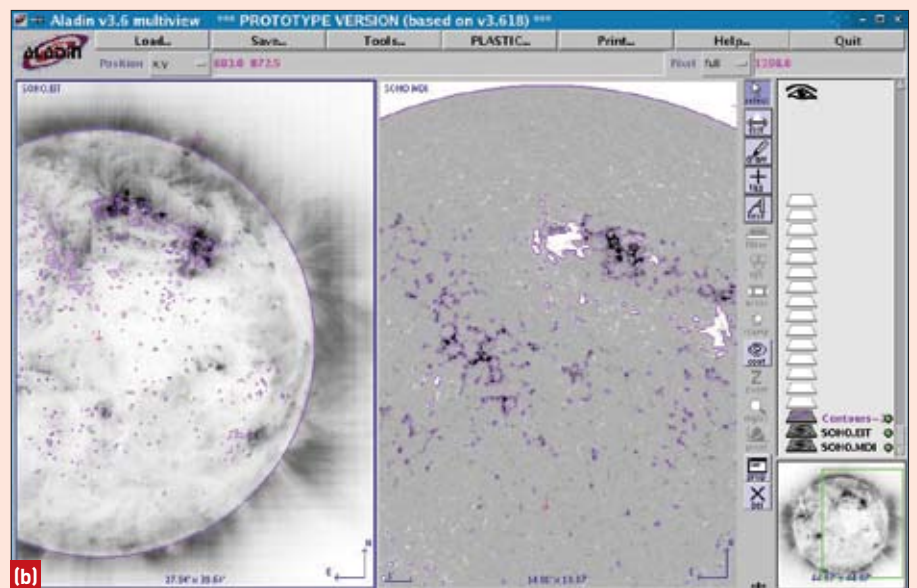
In the UK, AstroGrid aims to provide a complete Virtual Observatory Service to its astronomical community, providing a place to create science through access to data and applications, and a secure environment for data analysis and interpretation. The current AstroGrid VO service is in an early stage of release.

Over the coming years, AstroGrid and the VO will change the way that astronomical data is manipulated, supporting greater scientific exploitation of the superb quality observations of the sky which are now being obtained from major astronomical observatories. ●

Nicholas A Walton, Eduardo Gonzalez-Solarez, Univ. Cambridge; Silvia Dalla, Anita Richards, Univ. Manchester; Jonathon Tedds, Univ. Leicester. This paper is written on behalf of the AstroGrid team (funded by PPARC science) a consortium of 11 UK institutes: Institute of Astronomy, Cambridge; Institute for Astronomy, Edinburgh; Dept of Physics and Astronomy, Leicester; Mullard Space Science Laboratory, University College London; Jodrell Bank Observatory, Manchester; Dept of Computer Science, Royal Holloway University of London; Space Data Division, Rutherford Appleton Laboratory. In AstroGrid2 (Jan 2005 – Dec 2007), four additional institutes joined: Dept of Physics, Bristol; School of Physics, Exeter; School of Computing, Leeds; Institute of Cosmology, Portsmouth.

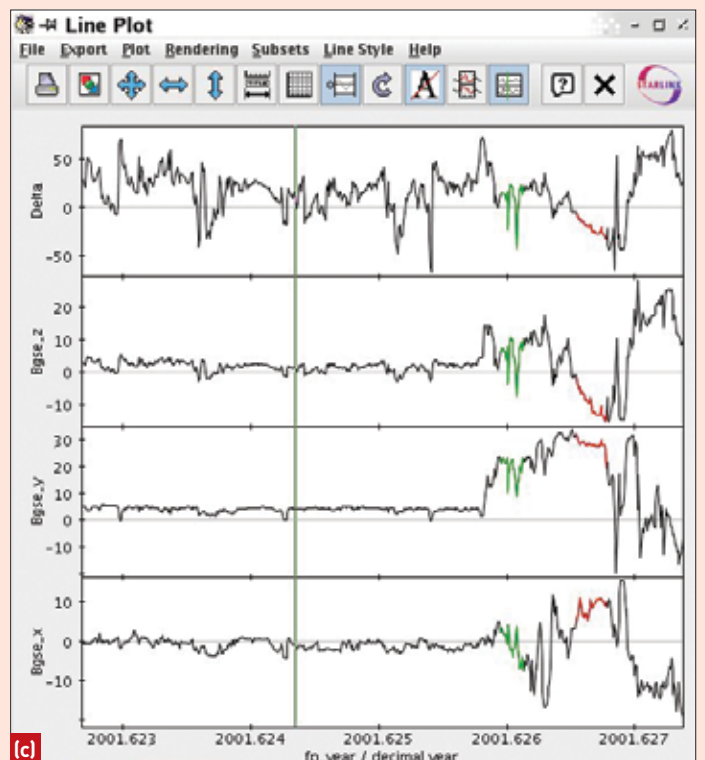


(a)



(b)

3 (a): This shows the use of HelioScope, with a time search returning access to a range of data resources. (b) Image data visualized using Aladin. (c) Temporal spectral data analysed with Topcat (exploiting its line plot capability).



(c)