Science Requirements for the AVO Early Demonstrator

Suggestions for Capability.

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Summary.

Two top level science drivers are considered and from these two tools are suggested for development as part of the AVO's Spring 2003 capability release.

1. Working Group (WG) Remit.

This working group was set up by the AVO SWG at its June 12 2002 meeting. It's remit was to suggest possible science drivers and required functionality to meet these. This would input into the construction of AVO products to be released as its early capability demonstrator. This release is scheduled for the first half of 2003.

1.1. The WG was asked to consider two main areas focusing on Cosmology and nearby Galactic astronomy.

1.2. As discussed in the meeting of Feb 7, 2002, the GOODS programme was considered a suitable source programme to represent the 'cosmology, deep astronomy case'

1.3. Likewise, the Magellanic Clouds were taken to represent the 'galactic astronomy' case.

1.4. Tools to be developed for the early science demonstrator must, on the one hand be of general use to the community, irrespective of subfield, and on the other hand be particularly useful to existing science teams and therefore of immediate importance for their ongoing projects.

2. The Cosmology Case.

2.1 Science Drivers

The Great Observatories Origins Deep Survey (GOODS) is a public, multi-wavelength survey that will cover two 150 arcmin2 fields. These fields are centred around the HDF-N (Hubble Deep Field North) and the CDF-S (Chandra Deep Field South).

GOODS was originally based around a SIRTF Legacy programme (providing deep IR data) and a HST/ACS Treasury Programme, designed to study galaxy formation and evolution over a very wide range of cosmic look-back time. GOODS will help in understanding the evolution of galaxies and their stellar populations by providing data on 'ordinary' galaxies in the redshift range $1<z<6$.

2.2 The GOODS programme data availability.

All GOODS data will be made publicly available to the global astronomy community. Data is being obtained with many premier observing facilities, including:

X-Ray:		Chandra and XMM-Newton
Optical/UV:		HST/ACS
	ESO:	VLT/VIMOS, VLT/FORS, WFI@2.2m
	NOAO:	4-m MOSAIC, FLAMINGOS, MMT/Minicam
	CTIO:	4-m MOSAIC
near-IR:		ESO: VLT/ISAAC, NTT/SOFI
mid IR:		SIRTF

Currently available data includes ESO VLT/ISAAC, Chandra and NOAO/CTIO data sets. SIRTF will provide data from Q2 2003. There will be a steady flow of new data appearing before the end of 2003.

2.3 Suggested requirement on Tool Capabilities.

The GOODS programme is of prime importance for the AVO to demonstrate a provision of capability in an early feature release. GOODS represents a source of existing and future multi-passband data which will all be publicly available to the global community.

A significant aspect of the GOODS programme is the fact that early datasets need to be analysed in order to define sample subsets (e.g. samples of galaxies at specific redshift intervals, starburst galaxies, etc). These will be investigated in more detail with later observations, often multi-object spectroscopy.

A suitable AVO tool could have a major impact in this area of selecting objects for spectroscopic follow-up. In addition, the proposed tools will also be useful for initial identification/classification of the sources in a given field. The proposed tools would have more wide spread benefit to many programmes where multi-wavelength data sets are available.

The GOODS data will present issues where confusion limited data is being compared with non confusion limited data in other bands. For instance the 24um SIRTF data will be confusion limited. The optical HST/ACS data will be needed to help in determining the sources in the SIRTF data.

Thus, two main tools are proposed by the subgroup of the AVO SWG:

2.3.1. A Spectral Energy Distribution (SED) fitting tool.

It is proposed that this tool extracts the appropriate area from multi-passband archival data (specified by the user), and obtains fluxes in each passband.

The SED tool proposed here would act on the pixel data (in contrast to SED tools available e.g. through NED - see http://nedwww.ipac.caltech.edu/forms/photo.html - which access only published flux data points).

The construction of the SED tool will require:

- high-quality astrometric matching of data sets
- archival data with the appropriate header keywords to convert the count rates in the images to standardised fluxes.
- ability to return a reliable upper limit on the flux when there is no detection of the object in a particular passband. This will need to be based on the limiting magnitude for the data which may need to be estimated.

The recommended output of this tool consists of:

(1) a simple plot of the retrieved SED obtained from the individual image data points, with the best-fitting composite template SED over-plotted (e.g., of the appropriate type of spiral or elliptical galaxy, star-burst, etc.) This will therefore require access to a database containing such template spectra. A simple least-squares type optimisation algorithm will also need to be implemented.

(2) postage stamp-type images of the area in all passbands. Ideally, one should be able to have access to these in a 3D sense (a data-cube), so that strange and unexpected results can be assessed easily by 'flying' through the data-cube.

(3) Additional capability would be in enabling the inclusion of spectral data with the photometric data - important when e.g. VIMOS/FORS spectra are available.

Some of the functionality of this tool is already available, either from the ASTROVIRTEL effort, from Aladin, or from other archival resources.

It is noted that a visualisation capability needs to be developed to enable the 'fly-through' visualisation of the multi-colour pixel data cut-outs.

2.3.2. A colour selection tool.

A powerful addition to the SED fitting tool, and a natural extension, will be a colour selection tool, in which the user can plot two user-specified colours of catalogue sources against each other in a colour-colour plot. This will help spot outliers, which are of most likely interest for follow-up spectroscopy.

Part of the required functionality for this tool, in addition to that already needed for the SED tool, will be a tool to construct a source catalogue in a given field. Such tools exist already and can likely be easily included in the AVO tool.

3. The nearby 'Galactic' Case: The Magellanic Clouds

3.1 Science Drivers for the nearby 'Galactic' Case: The Magellanic Clouds

The study of the Magellanic Clouds, including the interactions between the LMC, SMC and our Galaxy, can give answers to a number of important astrophysical questions. The LMC and SMC are useful laboratories because they are nearby, interacting, and contain a wide variety of, and often resolved, objects and events such as starburst regions, giant shells, young stellar arcs. Many of these point to recent episodes of star formation. Further the LMC and SMC sample varying degrees of underlying metallicity.

The LMC and SMC can be used to support studies such as:

- The spatial distribution of the various components and their correlation: e.g. distribution of stellar components such as: Carbon stars, Planetary Nebulae, star clusters and associations, stellar complexes, Cepheids, other variables, SNRs, etc. correlation of extended emission and star formation.

- The time variation of the large scale structures of these galaxies.

- The kinematics and morphology of the Magellanic Clouds.

A key difference in the study of the Magellanic Clouds as opposed to 'deep' fields, is that many sources will be extended and/or located in regions of high/low extended background (extended HII emission, molecular clouds etc).

3.2 Data Sets

Currently available public data surveys include:

Optical: USNO2A, GSC II, UCAC, NOAO Microlensing Survey
IR: DENIS, 2MASS, IRAS, ISO

Radio: HI (Parkes, ATCA)

Other data: (see http://vizier.u-strasbg.fr/MC2/data.html)

Spectral types
Radial Velocities
Metallicities
Light curves (EROS, MACHO)
Simulations (published models)
Spectral classification of stars (from automatic algorithms)

3.3 Suggested Requirement on Tool Capabilities

It is proposed to present to the AVO-user an innovative set of data services and tools for exploring the chemical and dynamical evolution and the stellar contents of these two satellites of our Milky Way, and for studying the time variation of their various components in order to trace the effects of their close encounter and their close passages to our Galaxy.

This can be achieved by combining the data from many complementary multi-wavelength archives (images as well as data holdings; recently published catalogues and datasets; etc.) and using a set of analysis and visualisation tools

It is expected that the tools relevant to the 'Cosmology' case (see 2.3.1 and 2.3.2) would also be relevant here. However, the priority in this case would be the user defined colour-colour tool (2.3.2).

For the case of the SED tool, a specific requirement would be the ability for the user to define background apertures for flux subtraction around point sources, in determining the flux in a point (as the background maybe varying around the object of interest).

Many publicly available MC data sets (e.g. OGLE, NOAO) focus on repeat observations of the MC (lensing studies). Thus the SED tool will need to be able to generate SED's not only on the multi-wavelength data but also on the multi-temporal data. Thus the ability to handle time stamped input data will be important.

4. General notes

The tools proposed by the AVO SWG subgroup are of more general use than just for the two projects discussed. In fact, they are mutually useful between these projects, and easily extendable to other projects (e.g., the Galactic plane region, the Orion Nebula area, QSO search, etc.).

We propose, however, to focus on the GOODS and the MC projects, because:

(1) the GOODS project in particular represents an ongoing and innovative project, with a lot of potential for future use by archive users.

(2) Several teams are actively exploring the data for both areas, so that an AVO tool would most likely be put to immediate use.

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