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GIPSY 3D: Analysis, Visualization and VO Tools for Datacubes

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Abstract. The scientific goals of the AMIGA project are based on the analysis of a significant amount of spectroscopic 3D data. In order to perform this work we present an initiative to develop a new VO compliant package, including present core applications and tasks offered by the Groningen Image Processing System (GIPSY), and new ones based on *use cases* elaborated in collaboration with advanced users. One of the main goals is to provide local interoperability between GIPSY and other VO software. The connectivity with the Virtual Observatory environment will provide general access to 3D data VO archives and services, maximizing the potential for scientific discovery.

1. Introduction

The AMIGA[3] (Analysis of the interstellar Medium of Isolated GAlaxies) project is an international scientific collaboration led from the Instituto de Astrofísica de Andalucía. It focuses on a multiwavelength analysis of a statistically significant sample of isolated galaxies, in order to provide a pattern of behaviour to the study of galaxies in denser environments.

Since intensive analysis of 3D data is needed and given the experience acquired by the group in radio-VO developments (Ruíz et al. 2009), a collaboration has started with the Kapteyn Institute for upgrading the GIPSY[4] software in order to produce a friendly VO-compliant package for high-level analysis of datacubes, with applicability to different multidimensional datasets and wavelengths. The final result will provide a more efficient way to treat data cubes, and will allow a way to get more and better science out of the data.

2. The Groningen Image Processing System (GIPSY)

Three-dimensional datasets are the result of obtaining spectral information over a two-dimensional field of view. Present and future spectroscopic instrumentation, such as radio interferometers (including ALMA as well as other future radio facilities), Fabry Perot instruments and Integral Field Units in optical and

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[3]http://www.iaa.es/AMIGA.html

[4]http://www.astro.rug.nl/_gipsy/index.html

NIR telescopes provide 3D information on gas and stars in galaxies. These complex data provide a wealth of information, but are at the same time much less exploited by the astronomical community due to their complexity.

The Groningen Image Processing System (van der Hulst et al. 1992; Vogelaar & Terlouw) developed at the Kapteyn Astronomical Institute, is one of the more mature and powerful systems available to analyze and visualize multidimensional data, and supports a large variety of coordinate systems. It is especially powerful at performing analysis tasks and galaxy modelling, providing a wide collection of physical parameters in order to set up a detailed kinematical study of the gas. Paradoxically, the large number of parameters that can be fixed and/or determined in the analysis process is at the same time its power and its bane. Management and selection of such parameters is not sufficiently transparent and user-friendly for non-experts to fully benefit from the software and its full capability.

At this moment, GIPSY needs improvement of the graphical user interfaces for user interaction with the data, detailed documentation and an easily installable and maintainable system. Preserving the core functionality (i.e. applications for modelling rotation curves, interactive inspection and characterization of 3D data, etc.) is of the utmost importance because these functionalities are sparse and mostly absent in other image processing packages for astronomy.

The recently added Python bindings allow for the unique combination of the existing high-level core applications and state of the art new libraries which ensures an efficient way to improve graphical user interfaces, include VO functionality, and amend new data structures without the need to rewrite the core.

3. VO Tools

In order to make GIPSY available to a larger scientific user base than the specialized radio astronomy community it is essential to make a proper connection to the VO environment. The VO is changing the paradigm for how astronomical data are exploited; not only are more data available in a uniform way, but also tools allowing exploitation of large volumes of data by astronomers from different communities are being delivered continually.

Interoperability is the *Rosetta Stone* of the VO. It does not only allow concurrent access to distributed, heterogeneous data, but also enables VO software to communicate. The Simple Access Message Protocol (SAMP; Allan et al. 2008) offers new VO tools with all of the functionality coming from existing VO packages. Since they can communicate and share data sets, they form a huge collection of VO meta-software in a continuously evolving ecosystem. Local interoperability with other VO software and access to VO archives will allow not only efficient multi-wavelength dataset comparisons but also the possibility to contribute to and benefit from this growing ecosystem of VO software, services and data.

4. 3D VO Archives and Services

The increasing popularity of 3D data will result in an ever growing number of 3D VO archives. But because of the size and complexity of these datasets,

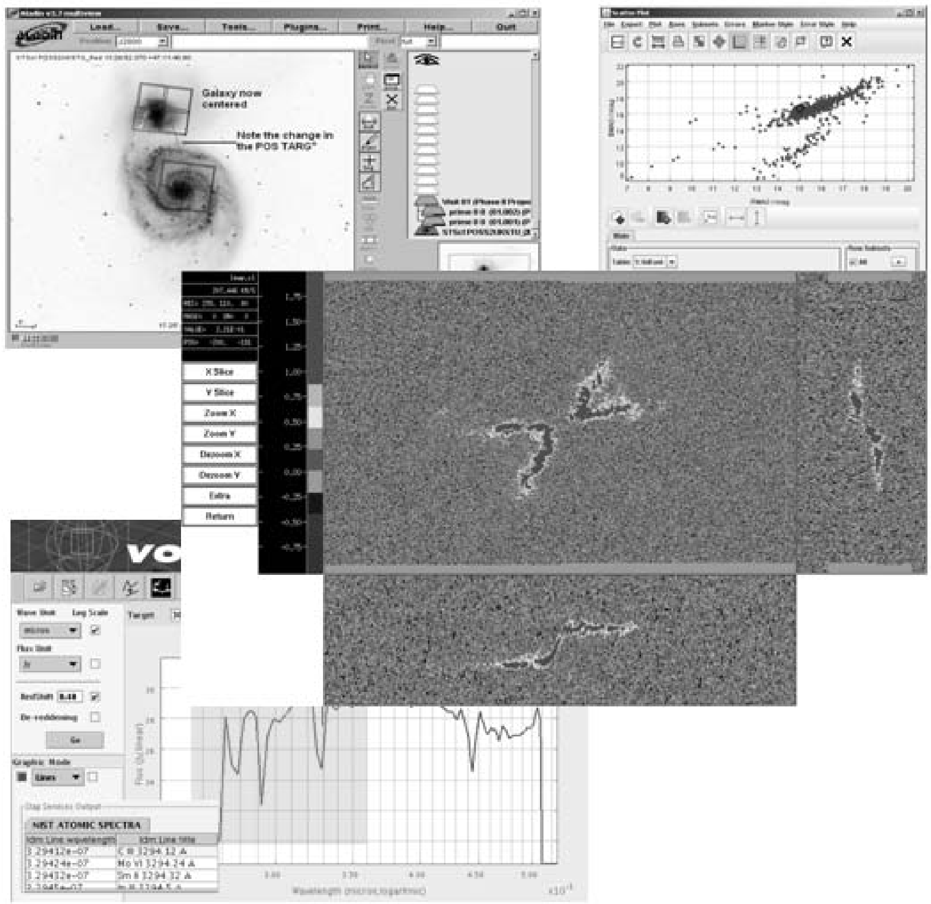

Figure 1.: GIPSY package will communicate with existing VO tools thanks to local interoperability.

data providers should supply on-line processing and analysis, and at the same time must have the capacity to store huge volumes of datacubes (Miller 2007). Among the main issues and challenges that have to be addressed are: a data description model for datacubes in the VO, a storage format unification for 3D files and mature standard VO protocols for 3D discovery and data transmission.

We will study the feasibility of implementing GIPSY on the server in order to supply VO services based on distributed computing analysis for a distributed storage 3D VO archive. The European OPTICON Network 3.6 and the National Virtual Observatory (NVO) project in the US, with the participation of several other groups, have provided a common desktop and server framework to bring data processing and analysis software into a common environment (Grosbøl & Tody 2006). As the GIPSY 3D project shares its philosophy, it must be fully compliant with this environment and must be taken into account from the very beginning.

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