

ASOV REVIEW: EXAMPLES OF VO TOOLS AND SERVICES: CASSIS, ALADIN AND ISMDB

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Abstract. The CASSIS emission line analysis package (developed at IRAP in Toulouse) and the Aladin interactive sky atlas (developed at CDS in Strasbourg) are examples of french Virtual Observatory tools that blossomed over the past few years. We illustrate some of the interactions between CASSIS, Aladin and e-infrastructures such as VAMDC, and presents the Interstellar Medium Database (developed at Paris Observatory) that gives access to Photo-Dissociation Regions models.

Keywords: VO-tools, database

1 Introduction

The advent of high spatial and spectral resolution as well as wide band instruments has left the astronomers with an over-whelming amount of rich spectra (data cubes in the case of interferometric observations). The analysis of such datasets is tedious and time consuming, without adequate tools and databases. The International Virtual Observatory Alliance (<http://www.ivoa.net>) has defined sets of standards to access, in a transparent and interoperable way, to the wealth of data in astrophysics. Today, major data centers of the discipline and many data publication services in observatories and laboratories are compatible with these standards. French teams are very active in these efforts at the international level. Here, we present two of the major french VO-tools CASSIS and Aladin as well as the Interstellar Medium Database.

2 CASSIS

The advent of high spectral resolution and wide band instruments has left the astronomers with an almost over-whelming amount of rich spectra. The analysis of such datasets would be tedious and time consuming, without adequate tools. The CASSIS line analysis package (Centre d'Analyse Scientifique de Spectres Instrumentaux et Synth tiques) has been designed at IRAP to help the astronomer with these tasks (Vastel et al. 2015), with a focus on studies of emission lines. The tool can be retrieved at <http://cassis.irap.omp.eu>. We presented the tool during the 2017 SF2A meeting, and the link between databases and inter-operability with Aladin and ISMDB in a near future.

CASSIS uses the SSAP protocol (Single Spectral Access Protocol) to access the IVOA services in order to retrieve any spectra (Hubble, Corot, Splatalogue, ISO, etc; the complete list can be found at <http://registry.euro-vo.org>). Also CASSIS uses the SAMP messaging protocol (Simple Application Messaging Protocol) that enables astronomy software tools to inter-operate and communicate. CASSIS can visualise FITS spectra, as well as spectra obtained with the CLASS/GILDAS software, and identify any molecular species present in the JPL, CDMS, NIST etc... databases and also through the VAMDC (Virtual Atomic and Molecular Data Centre) TAP protocol.

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Radiative transfer is also dealt with inside CASSIS. All the details on the theory can be found on the website (Formalism for the CASSIS software, author: C. Vastel). Any prediction of spectra can be done from many telescopes provided by the software, using the spectroscopic databases (frequencies, energy levels, statistical weights, Einstein coefficients). Presently a Local Thermodynamic Equilibrium (LTE) model as well as the non-LTE RADEX code (van der Tak et al. 2007) are available. Scripts for the spectral residual minimization (models vs. observations), via regular grid models or using the MCMC algorithm, are also available to retrieve best fit parameters such as the kinetic temperature, the density, the column density, the linewidth and the velocity of the observed species.

CASSIS collaborates with many tools through VO protocol. We present in Fig. 1 an example resulting from the collaboration between CASSIS and Aladin (see Section 3) Applauncher which is a product from OSUG (Jean-Marie Mariotti Centre), as well as F-VAMDC with the The Vienna Atomic Line Database (VALD). The spectrum viewed with the CASSIS interface corresponds to a hydrogen Ly α transition observed with the Hubble Space Telescope (HST) towards the Quasi Stellar Object 1257+2840. VALD is then selected and the spectrum shows the Hydrogen Lyman α transition at its rest frequency (green tick) and a less intense redshifted one on the right. Selection in the database can be made based on the upper level energy and Einstein coefficient of the transitions, as well as on the V_{LSR} of the source, which has an impact on the rest frequency of the transitions. A more detailed description can be found as an Euro-VO tutorial: http://www.euro-vo.org/sites/default/files/documents/Abell1656_final.pdf

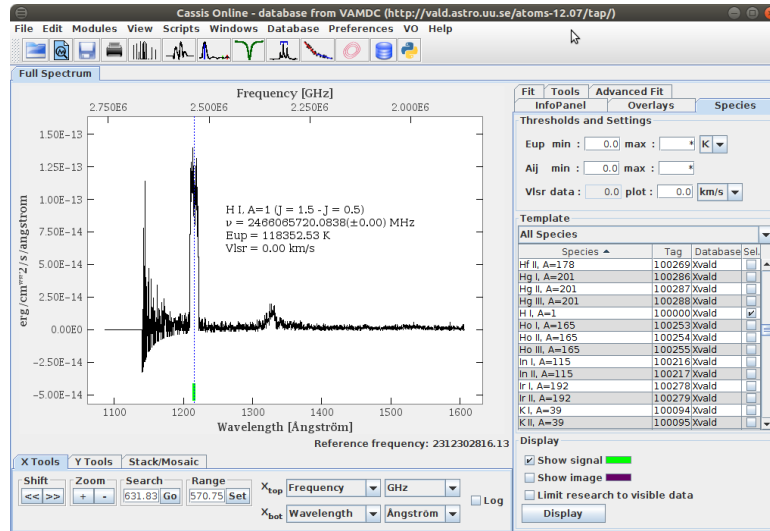


Fig. 1. CASSIS view of the hydrogen Lyman α transition observed towards QSO 1257+2840 using HST. The green tick corresponds to the line found in the wavelength range of the VALD database for HI.

3 Aladin

Aladin is an interactive sky atlas developed by the Centre de Données de Strasbourg (CDS). It focuses on visualising images, accessing data and overlaying information. As such, it is one of the portals to the Virtual Observatory. Aladin is currently ongoing a major update with v10. This new version builds on the definition and evolution of HiPS (Hierarchical Progressive Surveys) and MOC (Multi-Order Coverage) standards (Fernique et al. 2015) and their full capabilities. This translates into new possibilities to access all data available (images, catalogs, ...) and includes keyword searches in the wealth of accessible resources. A new interface for Aladin v10 has been developed to highlight these changes, but the tool remains focused on image visualisation and data access and users will still find the data they loaded in the stack on the right with a list of functionalities and the main view at the center. An example of the view in Aladin v10 is shown in Fig. 2

Thanks to the usage of the HiPS and MOC standards, new scientific uses of Aladin can be achieved with great efficiency that would be very hard to do otherwise. An example of such a usecase is the following question: given a set of observations or a set of images of interest (e.g. images from the MASH planetary nebula catalog; Parker et al. 2006), I would like to find regions among these that are at low extinction, find the sources in

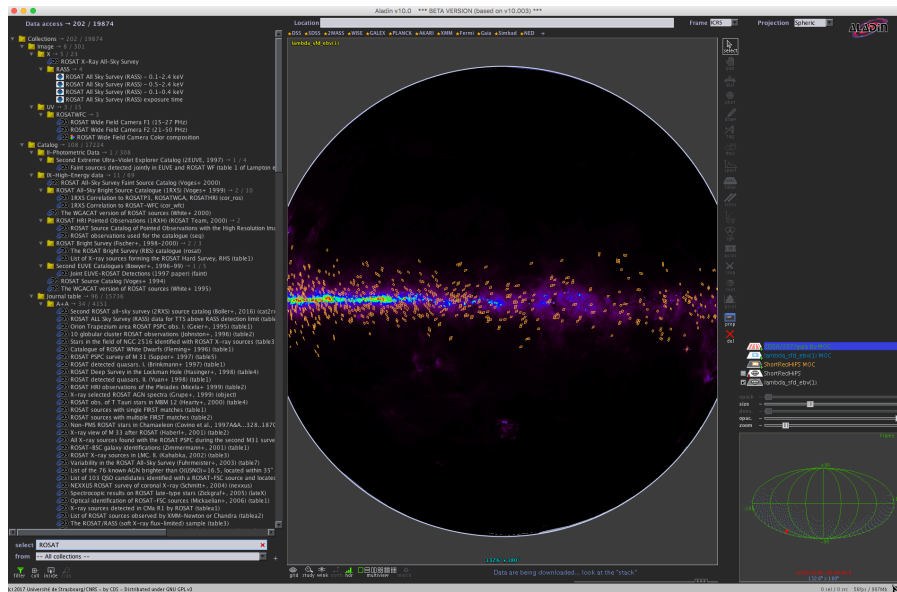


Fig. 2. The new Aladin v10 interface. The data loaded is displayed on the left in the stack and viewed at the center. On the left, a new column enables the user to search through the wealth of all available data (images, catalogs, ...). Search by keywords is shown at the bottom left.

these fields that were detected both by WISE (Cutri & et al. 2012) and Gaia DR1 (Gaia Collaboration 2016) and visualize physical quantities (e.g. a color-color diagram). Completing this scientific case requires to: 1) find the sky coverage that is the intersection of the set of MASH Short-Red images and of the sky coverage corresponding to $E(B - V) < 0.5$ as drawn from the Schlegel et al. (1998) HEALPix map, 2) load the Gaia DR1 catalog sources in the previously defined regions only (query by MOC), 3) X-match the loaded sources with WISE catalog and finally, 4) visualize the Gaia-WISE color-color diagram thanks to the interaction with other VO tools like TOPCAT. The full usecase can be done in half an hour with Aladin V10 and is described step-by-step as a tutorial available at <http://www.euro-vo.org/?q=science/scientific-tutorials>.

The presentation of this user-case is a demonstration that Aladin V10 enables an advanced scientific usage thanks to HiPS and MOC standard and their hierarchical properties on the full sky. This opens a new way to access and interact with data. Furthermore, Aladin V10 gives a fast access to the CDS X-match service. Finally, Aladin V10 keeps the same interoperability with all VO services as it previously. With all these characteristics, we believe Aladin V10 has a large potential for scientific usage that we encourage users to explore. Aladin V10 will be released in October 2017 and is currently already available as a beta version.

4 ISMDB

The Interstellar Medium Database (ISMDB) is developed at Paris Observatory (<https://ism.obspm.fr>). This service is based on the IVOA standard SimDM (Simulation Data Model). The goal of ISMDB is to publish state-of-the-art numerical models to prepare and interpret observations in the molecular interstellar medium. Presently, the system gives access to ~ 3000 PDR models (PDR: photo-dissociation region) computed with the Meudon PDR code (<http://pdr.obspm.fr>). For each model, defined by physical parameters such as the gas density and the intensity of the UV radiation field, ISMDB gives access to observables such as line intensities of atoms and molecules (C^+ , C, O, H_2 , CO and its isotopologs, HCN, HNC, H_2O , ...) as well as column densities. It is also possible to download the full data produced for each model to get access to the simulated structure of the PDR model: profiles of gas and grains temperature, density profiles of chemical species, ...

Compared to standard databases, the originality of ISMDB comes from the fact that we wish to build a system in which a scientist would be able to provide observed quantities (ex: atomic or molecular line intensities), and the machine would find by itself models able to reproduce these observations. So, in a certain way, we tried to bring “intelligence” on the server side. We achieved this goal moving data to metadata. A run of a PDR code computes thousands of physical quantities (ex: thousands of line intensities, thousands of column densities, in

quantum levels for hundreds chemical species when needed). Instead of using only input parameters of each run as metadata, as done usually, we added the most important data to this list of metadata. The total number of metadata per model is about 150 000. We developed our own technology to store and manage such high-dimension data. To allow the interaction between a human and a large number of physical quantities available in the system, we developed SKOS vocabularies to tag each metadata by a concept and a list of synonyms. The web interface of ISMDB contains a "google bar" in which the user type the name of a quantity he is looking for (ex: for line intensity of CO, users may start typing $I(\text{CO} \dots$ or *intensity CO ...*). While the user is typing the quantity name, a semantics interpreter searches for a match between this entry and the vocabulary to help him to find the name of the quantity as known by ISMDB. Once users have provided observed line intensities or column densities, possibly with errorbars, in the ISMDB web-interface, ISMDB searches in its high-dimension database the best models that match the observations. Results are provided nearly immediately since all pieces of necessary information are stored as metadata. This is an important time saving for scientists. Running grids of such models yourself and comparing the results to observations to find the best ones usually takes weeks, whereas ISMDB gives a solution in a few seconds. In the future, we will continue to develop services above ISMDB. Presently, it is only possible to provide ISMDB with observations at one spatial pixel. We are developing a new service in which it will be possible to upload files containing line intensities on several pixels of a map to reclaim the best physical parameters (such as the gas density) at each pixel.

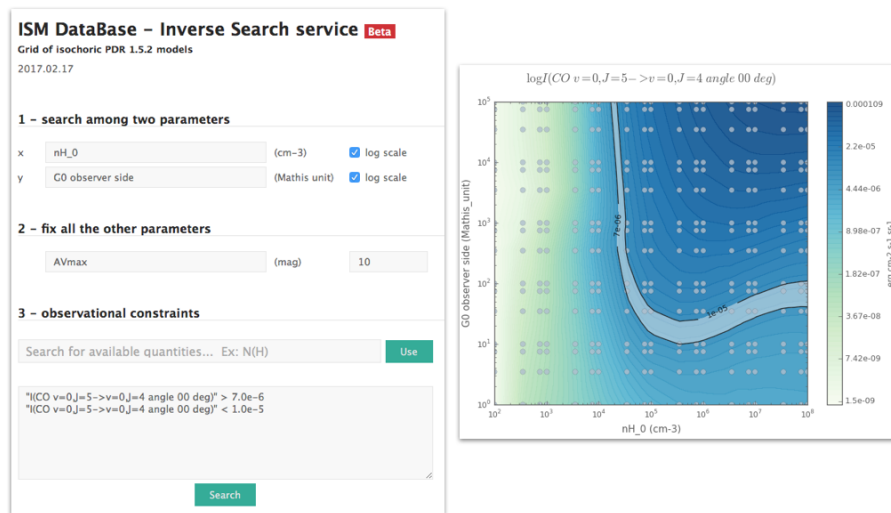


Fig. 3. ISMDB inverse search web interface. The users select the physical parameters the code will look for (ex: gas density and intensity of UV radiation field). Then, he enters some line intensities with errorbars. Finally ISMDB presents, in the relevant parameter space, the zone where models match observations best. Clicking on the bullets of the map, it is possible to download the corresponding models for further analysis.

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