Преглед НЦД 15 (2009), 52–58

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SERBIAN VIRTUAL OBSERVATORY

Abstract: We review the newly established project of Serbian Virtual Observatory. In the last few years Virtual Observatories are becoming a new concept in the world of astronomy. The main aim of Virtual Observatories is to make accessible astronomical data to astronomers regardless of their geographical location as well as provide them with tools for analysis. The project of Serbian Virtual Observatory aims to achieve the following goals:

1) establishing SerVO and join the EuroVO and IVOA
2) establishing SerVO data Center for digitizing and archiving astronomical data obtained at Serbian observatories
3) inclusion of BelData/STARK-B and other theoretical and simulated data in SerVO
4) development of tools for visualization of data

Introduction

Astronomy is very well positioned to exploit advances in the information technology. It comes from its early commitment to formatting standards i.e. flexible image transport system (FITS) came about in the mid eighties of the last century. Also, today astronomers universally use digital detectors which allow a much quicker acquisition of data. And, from the early days, astronomers were committed to data preservation and data reuse.

Virtual observatories are a fairly new concept in astronomy as international, community based initiative. Their origin can be traced to the NASA centers for mission oriented datasets in the early 1990's. Also, in the mid- nineties two large whole sky surveys appeared (2MASS and SDSS), so a large quantity of data became available for the general use. Originally the main aim of virtual observatories was to find, retrieve and analyze astronomical data from ground and space based telescopes worldwide.

Virtual observatories today combine research in different areas of astrophysics (some of which are fairly new):

multiwavelength astrophysics
archival research
survey astronomy
temporal astronomy

theory and simulations (comparisons with observations) and information technology such as

Moore's law (amount of information that can be processed doubles approximately every two years)

digital detectors

massive data storage

the Internet

data representation standards.

Virtual observatories are not only facilities for accessing data, but also provide data analysis techniques, common standards, wide network bandwidth and state of the art analysis tools. We can briefly compare the 'normal' and virtual observatories as follows. The 'normal' observatories have telescopes for gathering electromagnetic radiation or particles, instruments for analyzing and recording as well as different facilities for support of operation. The virtual observatories consist of data centers, loads of astronomical data, software systems and processing capabilities.

Organization of Virtual Observatories

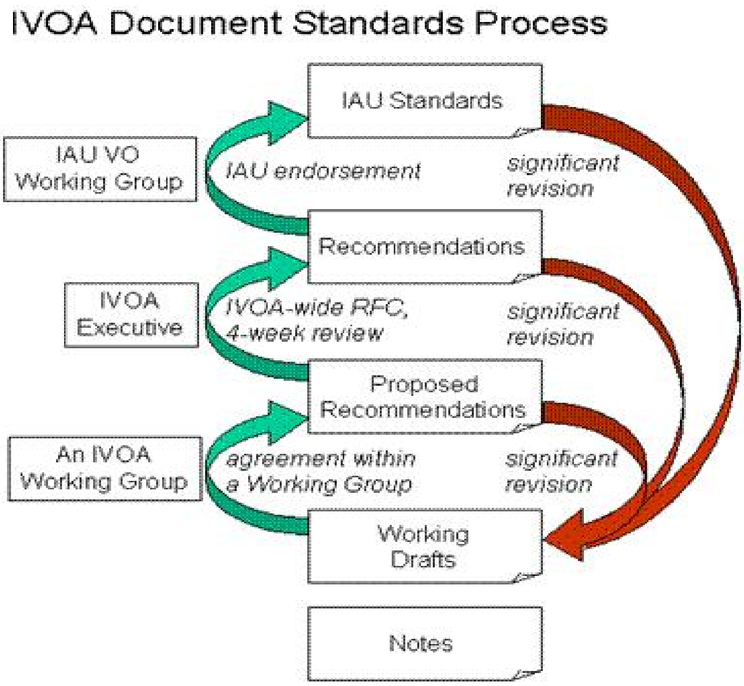

Fig.1. The process of IVOA definition and adoption of standards

International Virtual Observatory Alliance (IVOA, www.ivoa.net) is an organization which was formed in June 2002. Its mission is to facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory. So the work of the IVOA mainly focuses on the development of standards

Documents which define current set of standards as well as recommended ways of implementing them can be found at http://www.ivoa.net/Documents/

European Virtual Observatory - EuroVO is an organization which aims at deploying VO in Europe. Its main objectives are:

technology take-up
VO compliant resource provision
building the technical infrastructure
support its utilization by the scientific community

EuroVO is organized in three main parts as shown in Fig 2.

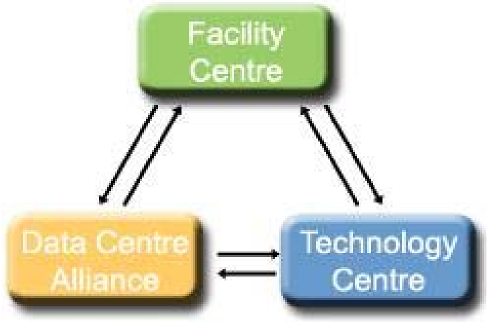

Fig.2 Organization of European Virtual Observatory

Facility center (VOFC) is an organization that provides the EURO-VO with a centralized registry for resources, standards and certification mechanisms as well as community support for VO technology take-up and dissemination and scientific program support using VO technologies and resources.

Technology center (VOTC) is a distributed organization that coordinates a set of research and development projects on the advancement of VO technology, systems and tools in response to scientific and community requirements.

Data Center alliance (DCA) is an alliance of European data centres which will populate the EURO-VO with data, provide the physical storage and computational fabric and which will publish data, metadata and services to the EURO-VO using VO technologies. Many types of contribution are possible in DCA : data archives, with a particular emphasis put on 'science ready' data; added-value databases, services; tools, software suites and algorithms, for instance for data visualization, data analysis and data mining; thematic services to help solving a well-defined science question; full data analysis or research environments. New types of services are emerging, within particular theoretical services, providing modeling results, or matching models with observations.

Serbian Virtual Observatory (SerVO)

Serbian virtual observatory is a new project whose funding was approved through a grant TR13022 from Ministry of Science of Republic of Serbia. The main aim of this project is to publish data obtained by Serbian astronomers as well as to provide astronomers in Serbia with VO tools for their research. In the first three years of the project the main goals are:

digitization and publishing in VO photo-plates from the archive of AOB
publishing STARK-B (Stark broadening data) in VO compatible format
publishing DSED (stellar evolution database) in VO

Photo plates

Photographic plates have a special historical, as well as scientific, significance for the astronomy. This has been recognized by the main astronomical governing body, International Astronomical Union, which adopted a resolution in year 2000, which stated that all historic observations should be preserved, digitized and make available for use to wide astronomical community [1].

Astronomical Observatory in Belgrade is one of the oldest scientific institutions in Serbia. It was formed in 1887. From the mid-thirties till mid-nineties of the last century photographic plates had been one of the recording media for the observations. During that time more than fifteen thousand plates were recorded, processed (at least partially), analyzed and archived. Different instruments and different photo plates were used during that time.

One of the main goals for the first couple of years of the operation of SerVO is to digitize a subset of plates obtained with the Zeiss astrograph (Fig.3) and publish it in the VO compatible format.

Various photo plates were used during around sixty years: Kodak (103aO, 2aO, 103aJ, 103aF), Ferrania Pancro anti-halo, Agfa Astro-Platten, Peruts Emulsion, Gevaert Super Chromosa, ORWO ZU 2 and ZU 21, Ilford etc. Also those plates were of different format, and variety of objects were observed.

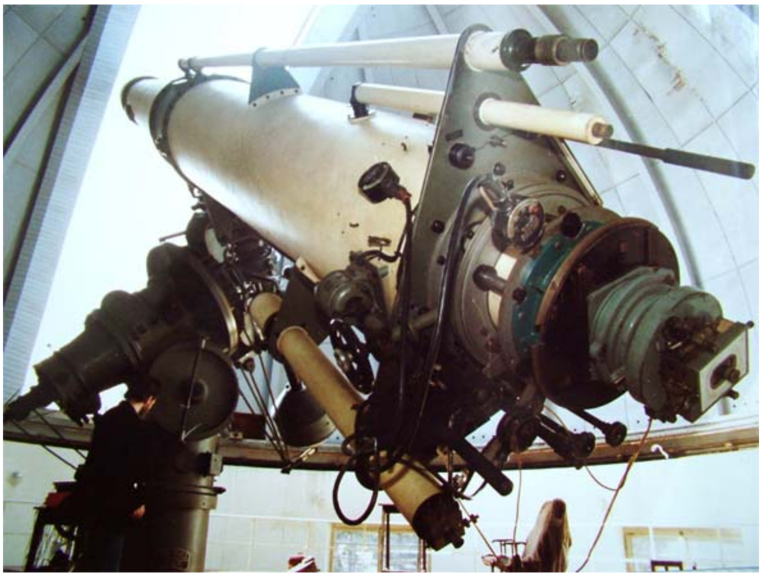

Fig. 3 Zeiss refractor

The digitization of plates is a two phase process. In the first phase, we intend to scan plates with medium resolution (i.e. 1200 dpi). After completion of this 'preview' phase, we will publish data in VO compatible format. The second phase consist of cleaning and scanning with high resolution (4800 dpi). This phase is somewhat flexible, as we intend to give the priority to plates for which a user demand exists. An example of a scanned plate is given in Fig. 5.

Of course each plate is going to be associated with metadata: plate number, date and time, instrument, observer, coordinates, coordinates of guiding star, method of observations, exposure time, focal length, type and format of plate, air temperature and quality of exposure etc. The metadata are extracted from handwritten records. The first results in archiving of photographic plates were presented in [2].

EURO-VO provides some tools, which are going to be used together with the standard software (SQL, JAVA, Perl etc,) to build an appropriate database. We expect to generate around five Tbyte of data in the first instance. Handling will be achieved using the Linux Software RAID array with Linux Volume Manager.

Fig. 4 Scanned photographic plate (from the very early datasets)

SerVO – BELDATA - STARK-B

Theory is a fairly new addition in the context of Virtual Observatory. At Belgrade Observatory there exist a large quantity of calculated data for Stark broadening parameters (line width and shift). This line broadening mechanism is generated by interaction of emitting/absorbing atoms and ions with charged particles.

BELDATA was a precursor of SerVO and its main content was database on Stark broadening parameters, which after intensification of collaboration with French colleagues around MOLAT database of Paris observatory became STARK-B. This database is devoted to metallization and spectroscopic diagnostics of stellar atmospheres. In addition, it is also devoted to laboratory plasmas, laser equipments, fusion and technological plasmas. So, the domain of temperatures and densities covered by the tables is wide and depends on the ionization degree of the considered ion. The temperature can vary from several thousands for neutral atoms to several hundred thousands or millions of Kelvin for highly charged ions. The electron or ion density can vary from 1012 (case of stellar atmospheres) to several 10^{19} cm^{-3} (of interest for subphotospheric layers, some laboratory plasmas and inertial fusion research).

The impact approximation and the isolated line approximation are applied, so that the line profile is Lorentzian. The basis for calculations is the computer code which evaluates electron and ion impact broadening of isolated spectral lines of neutral atoms and ions, using the semiclassical-perturbation approach developed by Sahal-Bréchot [4-6], and supplemented in [7]. This computer code has been updated by Dimitrijević and Sahal-Bréchot in their series of papers [8] and following papers.

The accuracy of the data varies from about 15-20 percent to 40 percent, depending on the complexity of the spectrum, degree of excitation of the upper level, and on the quality of the used atomic structure entering the calculation of scattering S-matrix leading to the widths and shifts. The more the upper level is excited, the semiclassical approximation is more suitable, but it is more difficult to find a sufficiently complete set of input atomic data.

The simple graphical interface to the data is provided (seehttp://stark-b.obspm.fr-/elements.php). A user first chooses the element of interest from the periodic system of elements. After that the ionization stage, perturber(s), perturber density, transition and plasma temperature can be set and page with description of data and a table with shifts and widths is generated. Two mirror sites, one in Meudon and one in Belgrade are planned.

The further development is going to be adaptation of the output to be compatible with the VO standards (which are yet to be fully defined) as well as to add more elements/ionization stages to the database. *

DSED in SerVO

The members of our team have contributed to the development of Dartmouth Stellar Evolution Database which was recently published [9,10]. It consists of evolutionary tracks and isochrones for initial stellar mass from one tenth to four solar masses. They were evolved from the pre-main sequence state to either of runaway fusion or 100 Gyrs. The metallicities considered were [Fe/H] from -2.5 to +0.5 and [α/Fe] -0.2 to +0.8 and the initial mass fraction of helium was changed from 0.25 to 0.4. Our contribution was in the calculation of the outer boundary conditions for the atmospheric structures using the general stellar atmosphere code PHOENIX. Using this kind of boundary conditions allows an easy generation of various parameters for population synthesis (i.e. colors , low dispersion spectra of star clusters and galaxies).

In the context of VO we intend to add an option of 'VO table output' for the whole set of data and host a mirror site at SerVO.

Visualization of data in ServVO

Part of our project is also providing the visualization tools for the easier and better access to the data from above databases. We plan to adopt some of already available tools from VO collection (i.e. for simple statistical analysis) and if necessary build new ones.

* Note added in proof: STARK-B database is included in the European wide Virtual Atomic and Molecular Data Center (VAMDC) – newly approved FP7 project.

Acknowledgment. The research presented in this contribution has been supported by the Ministry of Science and Technological Development of Republic of Serbia, through grant No. 13022/2008.

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