

## SERBIAN VIRTUAL OBSERVATORY AND VIRTUAL ATOMIC AND MOLECULAR DATA CENTER (VAMDC)

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**Abstract.** In this lecture we review recent developments in Serbian Virtual Observatory (SerVO) as well as its relation with the European FP7 project: Virtual Atomic and Molecular Data Center - VAMDC. Main components of SerVO are going to be the archive of photographic plates, database of Stark broadening parameters and stellar evolution database. Photographic plates were obtained at Belgrade Observatory from 1936 to 1996. Data for Stark broadening were obtained using semiclassical perturbation and modified semiempirical theories mainly in collaboration with Paris Observatory, and we are organizing them now in the STARK-B database, which will enter also in VAMDC, and will have a mirror site in SerVO. Serbian Virtual Observatory will contain as well a mirror of Dartmouth Stellar evolution database with improvements and VO compatible outputs.

### 1. VIRTUAL OBSERVATORIES AND SERBIAN VIRTUAL OBSERVATORY

The creation of datasets, connected with the space missions, in the NASA centers in early 90's, and the huge quantity of data obtained in large all sky surveys (2MASS and SDSS) in the mid-90's, available for the general use, posed the problem how to organize their search and use them for scientific

investigations. The idea of virtual observatory originated from the efforts to solve this problem. Today, the objective of virtual observatories is not only to find, retrieve and analyze astronomical data from ground and space based telescopes worldwide, but also to combine research in different areas of astrophysics, like e.g. multi wavelength astrophysics, archival research, survey astronomy... They also provide data analysis techniques, common standards, wide network bandwidth and state of the art analysis tools. For the differences of classic observatories which 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.

**International Virtual Observatory Alliance (IVOA)**, ([www.ivoa.net](http://www.ivoa.net)), is formed in June of 2002, with objective 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 its activity mainly focuses on the development and establishing of standards. The 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. It is organized in three main parts:

**Facility center (VOFC)** 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)** 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 centers who will populate the EURO-VO with data, provide the physical storage and computational fabric and who will publish data, metadata and services to the EURO-VO using VO technologies.

**Serbian Virtual Observatory (SerVO)** – (<http://servo.aob.rs/~darko/>) is a project, whose funding was approved through a grant TR13022 from Ministry of Science and Technological development of Republic of Serbia aiming to achieve the following goals:

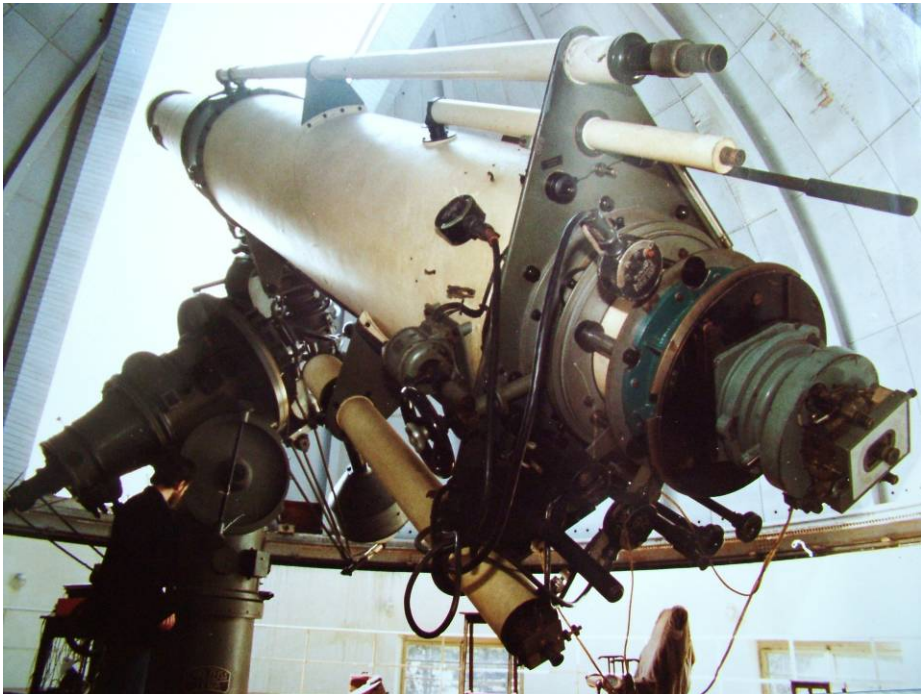
- 1) establishing SerVO and join the EuroVO and IVOA;
- 2) establishing SerVO data Center for digitizing and publishing in VO photo-plates from the archive of AOB, and publishing other observational, theoretical, and simulated data obtained at Serbian observatories or by staff of Serbian observatories;
- 3) development of tools for visualization of data.

## 2. PHOTO PLATES

International Astronomical Union adopted in 2000 a resolution, which stated that all historic observations should be preserved, digitized and made available for use of wide astronomical community.<sup>1</sup> In particular photographic plates, which have a special historical, as well as scientific, significance for the astronomy.

From the mid-thirties till mid-nineties of the last century, photographic plates had been one of the recording media for the observations at the Astronomical Observatory in Belgrade, one of the oldest scientific institutions in Serbia, founded in 1887. From this period, more than fifteen thousand archived plates exist, and one of the main goals of SerVO for the beginning, is to digitize them and publish in the VO compatible format.

During this period of around sixty years, were used photo plates: 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, and variety of objects were observed.

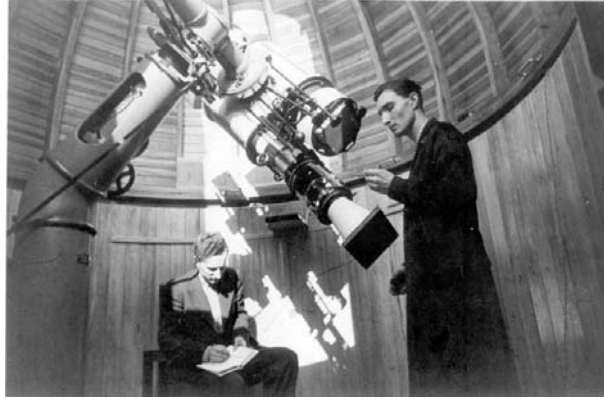


**Fig. 1.** Zeiss refractor (65 cm) of the Belgrade Astronomical Observatory.

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<sup>1</sup> Resolution B3 of XXIVth International Union General Assembly,  
<http://www.iau.org/static/publications/ib88.pdf> p.40

For the beginning we are scanning plates with medium resolution (i.e. 1200 dpi) and prepare them for publication in VO compatible format. After completion of this 'preview' phase, we will scan them with high resolution (4800 dpi). In this phase, since the preview will be accessible on the SerVO, we will scan in priority the asked by the users. An example of a scanned plate is given in Fig. 3.



**Fig. 2.** Zeiss astrograph. M. B. Protitch and his asisstantn M. Simić (1936).



**Fig. 3.** Scanned photographic plate (from the very early datasets).

The meta data on each plate will contain: 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. Meta data are extracted from hand written records. The first results in archiving of photographic plates were presented in Protić-Benišek et al. (2006). Together with standard software (SQL, JAVA, Perl etc.), some EURO-VO tools will be used to build appropriate database. Handling will be achieved using linux Software RAID array with Linux Volume Manager.

### **3. SerVO – BELDATA - STARK-B**

Theoretical data of interest for the modellisation and interpretation of various phenomena and objects in astronomy, are fairly new addition in the context of Virtual Observatory. The staff of Belgrade Observatory produced a large quantity of theoretical data for Stark broadening parameters (line width and shift), obtained mainly within the framework of fruitful collaboration with Observatoire de Paris in Meudon (MSD and SSB), lasting more than thirty years. This line broadening mechanism is generated by interaction of emitting/absorbing atoms and ions with charged particles.

The first attempt to organize these data, as well as other data existing at the Astronomical Observatory in a database, was the BELDATA project (Dimitrijević et al., 2003), the precursor of SerVO and its main content was database on Stark broadening parameters, which after intensification of collaboration between two of us (MSD and SSB) on the realization of this idea not in Belgrade but in Paris, and engagement of an informaticist (Nicolas Moreau) became STARK-B. This database is devoted to modellisation and spectroscopic diagnostics of stellar atmospheres as well as to laboratory plasmas, laser equipments, fusion and technological plasmas.

In the first stage, STARK-B (<http://stark-b.obspm.fr>) contains data determined using the semiclassical-perturbation approach developed by Sahal-Bréchet (1969ab; 1974), and the corresponding code, supplemented in Fleurier et al. (1977) and, Dimitrijević and Sahal-Bréchet (1984). 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. We note that the STARK-B database is included in the FP7 project European Virtual Atomic and Molecular Data Center (VAMDC). The data can be retrieved in two manners: as a text file or in VO table format.

#### 4. DSED IN SerVO

Members of the group for Astrophysical spectroscopy (DJ) participated also in the development of Dartmouth Stellar Evolution Database which has been recently published (Dotter et al., 2007, 2008). It consists of evolutionary tracks and isochrones for initial stellar mass from one tenth to four solar masses. They were evolved from pre-main sequence state to either of runaway fusion or 100 Gyrs. One of us (DJ) contributed to this project calculating the outer boundary conditions for the atmospheric structures using 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). We intend to add an option of “VO table output” for the whole set of data and host a mirror site at SerVO.

#### 5. VAMDC – VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

In order to enable an efficacious, productive and convenient search and mining of available atomic and molecular data and their adequate use, a FP7 founded project: Virtual Atomic and Molecular Data Centre (VAMDC – Dubernet et al., 2010), started on July 1 2009 with a budget of 2.9 MEuros over 42 months. Its aim are to build accessible and interoperable e-infrastructure for atomic and molecular data upgrading and integrating European (and wider) A&M database services and catering for the needs of variety of data users in science, research and development, and industry; creation of search engines that must look “everywhere” in order to map A&M Universe; and creation of a forum of data producers, data users and databases developers, as well as the training of potential users in European Research Area and wider.

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VAMDC

Virtual Atomic and Molecular Data Centre

**Fig. 4.** VAMDC logo.

Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Russia, England, Austria, Italia, Germany, Sweden, Serbia, and Venezuela.

Partners in the Consortium of the Project are: 1) The coordinator, Centre National de Recherche Scientifique - CNRS (Université Pierre et Marie Curie, Paris; Observatoire de Paris; Université de Reims; Université Joseph Fourier de Grenoble, Université de Bordeaux 1; Université de Bourgogne, Dijon; Université Toulouse 3); 2) The Chancellor, Masters and Scholars of the University of Cambridge – CMSUC; 3) University College London – UCL; 4) Open University – OU (Milton Keynes, England); 5) Universitaet Wien - UNIVIE; 6) Uppsala Universitet – UU; 7) Universitaet zu Koeln – KOLN; 8) Istituto Nazionale di Astrofisica – INAF (Catania, Cagliari); 9) Queen's University Belfast – QUB; 10) Astronomska Opservatorija - AOB (Belgrade, Serbia); 11) Institute of Spectroscopy RAS – ISRAN (Troitsk, Russia); 12) Russian Federal Nuclear Center - All-Russian Institute of Technical Physics - RFNC-VNIITF (Snezhinsk, Chelyabinsk Region, Russia); 13) Institute of Atmospheric Optics - IAO (Tomsk, Russia); 14) Corporacion Parque tecnologico de Merida – IVIC (Merida, Venezuela); 15) Institute for Astronomy RAS - INASAN (Moscow, Russia).

External VAMDC partner is also NIST – National Institute for Standards and Technology in Washington.

The main users of VAMDC facilities will be Astronomy, Plasma science, Atmospheric Science Radiation science and Fusion community as well as Industries using technological plasmas and Lightning industry

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