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For Session IV Educational Aspects of Computer Systems and Technologies:

- "Exploiting Eye Tracking in Advanced E-Learning Systems" by *Virginio Cantoni, Calet Jimenez Perez, Marco Porta and Stefania Ricotti*

For Session V Astroinformatics:

- "Serbian Virtual Observatory" by *Darko Jevremović, Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Veljko Vujičić, Vojislava Protić Benišek, Vladimir Benišek, Sylvie Sahal-Bréchot, Katya Tsvetkova, Jovan Aleksić, Siniša Nešković, Zoran Simić, Miodrag Malović*

Serbian Virtual Observatory

Darko Jevremović, Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Veljko Vujičić, Vojislava Protić Benišek, Vladimir Benišek, Sylvie Sahal-Bréchot, Katya Tsvetkova, Jovan Aleksić, Siniša Nešković, Zoran Simić, Miodrag Malović

Abstract:

The work on SerVO - Serbian virtual observatory (http://servo.aob.rs/~darko) started in 2008, with aims 1) To establish SerVO and join the EuroVO - European Virtual Observatory and IVOA – Inetrnational Virtual Observatory Alliance; 2) To create SerVO data Center for digitalization and archiving in VO format photo-plates from Belgrade Astronomical Observatory and other astronomical results obtained by the staff; 3) To develop the tools for visualization of data; 3) To develop together with Observatoire de Paris, STARK-B - database containing as the first step Stark widths and shifts of spectral lines, determined within the semiclassical perturbation approach by two of us (MSD-SSB) and to create a mirror site in Belgrade; 4) To make a mirror site for DSED (Darthmouth Stellar Evolution Database) in which development took part one of us (DJ). An additional aim is the creation of VAMDC (Virtual Atomic and Molecular Data Center) AOB (Astronomical Observatory of Belgrade) Node, and a recent objective is the collaboration with the Large Synoptic Telescope (LSST) project.

In this contribution SerVO project is reviewed within the context of e-science in Astronomy – Astroinformatics.

Key words: *Virtual observatories, Astroinformatics e-science, Atomic and Molecular data, Stark broadening.*

INTRODUCTION

The origin of the need for virtual observatories can be found in early 1990's in the development of the NASA centers for datasets from space missions and large all sky surveys (2MASS and SDSS). The original aim of virtual observatories (the idea was formulated at the end of 2000) was to, retrieve and analyze astronomical data obtained in various observatories and cosmic missions, but now they are used for research in different topics, like multi wavelength astrophysics, archival research, survey astronomy, temporal astronomy, comparisons with observations, and information technology as digital detectors and massive data storage. Virtual observatories also provide data analysis techniques, common standards, wide network bandwidth and state of the art analysis tools.

The basis for the creation of European Virtual Observatory - EURO-VO (http://www.euro-vo.org) was the FP5 project Astrophysical Virtual Observatory – AVO, which started in 2001. In order to enable the coordination necessary for the development of interoperability, standards, tools, systems and organizational structures needed for the international utilization of astronomical archives in virtual observatories. International Virtual Observatory Alliance (IVOA, http://www.ivoa.net) was formed in June of 2002.

In this contribution we review the project of Serbian Virtual Observatory (SerVO), its actual state and recent developments, as well as its relation with the european FP7 project: Virtual Atomic and Molecular Data Center – VAMDC.

SerVO – SERBIAN VIRTUAL OBSERVATORY

Astronomical Observatory in Belgrade is one of the oldest scientific institutions in Serbia, founded in 1887, by Milan Nedeljković. During the photographic era in Astronomy, from the mid-thirties untill mid-nineties of the twentieth century, more than fifteen thousand

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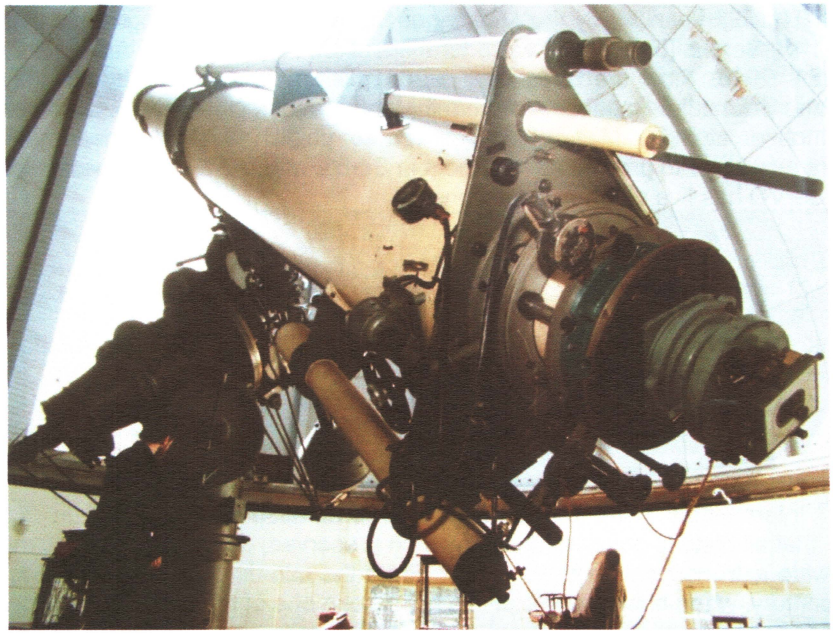

Fig. 2. The Zeiss refractor of the Belgrade Observatory

Fig. 3 A scanned photo-plate from SerVO

Academies (SANU and BAN) for the period 2004–2006. It was renewed for the period 2007–2009, and again in 2011.

SerVO - Serbian virtual observatory (http://www.servo.aob.rs/~darko) was founded as

plates were recorded, analyzed and archived in Belgrade, using different telescopes and different kinds of photo-plates.

Theoretical data of interest for the modellisation and interpretation of various astronomical spectra, plasmas and phenomena, are also within the context of Virtual Observatory, and during a fruitful collaboration of two of us (MSD and SSB), lasting more than thirty years, a large quantity of theoretical data for Stark broadening parameters (line width and shift), needed in particular for modellisation and analysis of astronomical spectra, was determined.

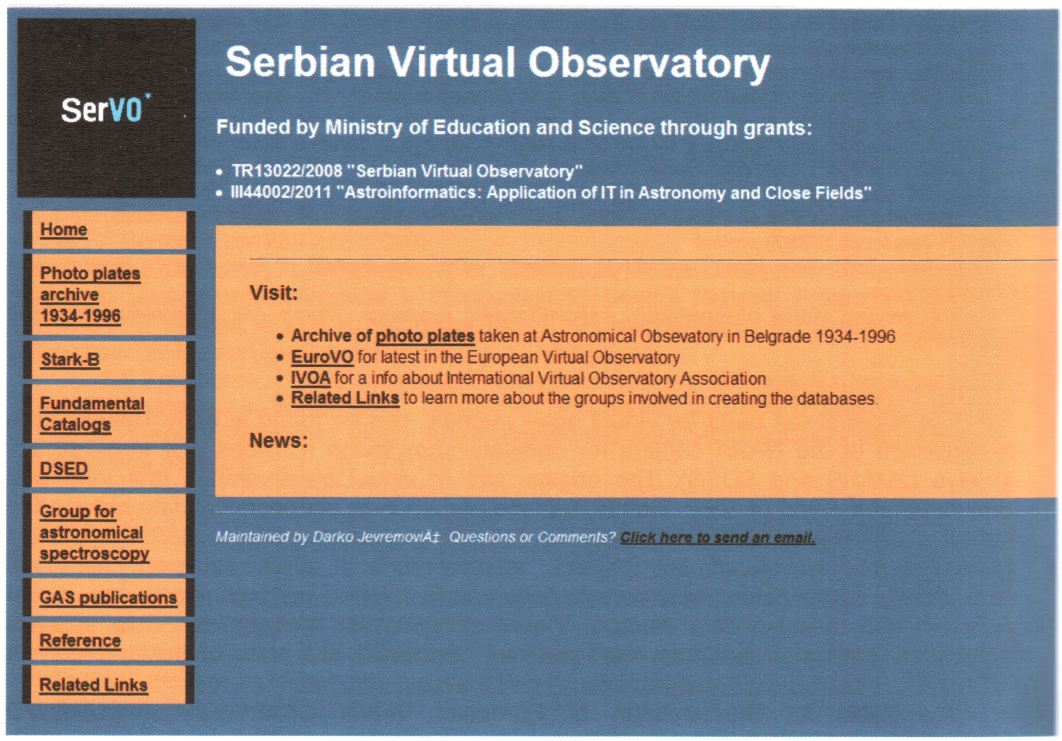

Fig. 1. Homepage of Serbian Virtual Observatory

At the end of nineties we started to think to organize the obtained Stark broadening data, as well as the other data accumulated in the Astronomical Observatory, in a database, and make them accessible to the international astronomical community through internet. The first such attempt, the precursor of SerVO, was the BELDATA project [2,3,13,14,15,16], containing as a first step a database with Stark broadening parameters, which, due to new conditions in Belgrade Observatory after 2002, was moved to Paris Observatory, and became STARK-B database.

For the development of Serbian Virtual Observatory, important is also the collaboration with Milcho Tsvetkov, Katya Tsvetkova and their team [27] who created Wide-Field Plate Database (http://www.skyarchive.org) in the Institute of Astronomy of Bulgarian Academy of Sciences in Sofia. This collaboration started in 1998, and was formalized in 2004, when the project entitled "Development and Application of Astronomical Databases" was signed between Astronomical Observatory of Belgrade and Space Research Institute of Bulgarian Academy of Sciences (where WFPDB was at that time), and entered within the frame of the cooperation between Serbian and Bulgarian

the project TR13022 financed by the Ministry of Science and Technological Development of Republic of Serbia [5,6,10,11], with duration of 33 months from April 1st 2008 till December 31st 2010. From the 1st January of 2011, SerVO is financed by the Ministry of Education and Science of Republic of Serbia through the project III44002 "Astroinformatics and virtual observatories". Main objectives are to publish data obtained by Serbian astronomers as well as to provide astronomers in Serbia with VO tools for their research.

Now, SerVO has five different collections:

1. Archive of photo-plates from the 1934-1996 period.
2. Link to, and the mirror site in construction of the STARK-B database.
3. Fundamental Catalogues
4. Link to, and the mirror site in construction of the DSED (Dartmouth Stellar Evolution Database) database.
5. Electronic editions of the GAS – Group for Astrophysical Spectroscopy

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PHOTO-PLATES

XXIVth International Astronomical Union General Assembly, adopted in 2000, a resolution, that all historic observations should be preserved, digitized and made available for use of wide astronomical community [18]. From the mid-thirties till mid-nineties of the twentieth century, when photographic plates have been one of the recording media for the observations at the Astronomical Observatory in Belgrade, more than fifteen thousand archived plates exist. They have a special historical, as well as scientific, significance for astronomy and one of the main objectives of SerVO, is to digitize them and publish in the VO compatible format

During this period different photo plates were used as: 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.

We begin with the scanning of photo-plates with medium resolution (1200 dpi) and preparing them for publication in VO compatible format, for preview. Then we will scan them with high resolution (4800 dpi). In this, second phase, we intend to give the priority to plates for which exist user demand. An example of a scanned plate from SerVO is given in Fig. 3.

On each photo-plate are the corresponding meta data, extracted from hand written records, namely 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. [26]. The first results in archiving of photographic plates were presented in [17].

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.

Now, in SerVO are scanned photo-plates obtained with three telescopes: Zeiss astrograph, Ascania refractor, and 65 cm Zeis refractor with Tessar and Petzval camera. An example of scanned plate is given in Fig. 5.

STARK-B DATABASE

The database STARK-B is available on line at the web address http://stark-b.obspm.fr/ and is further developing by Laboratoire d'Etude du Rayonnement et de la matière en Astrophysique of the Observatoire de Paris-Meudon (Sylvie Sahal-Bréchot and Nicolas Moreau) and the Astronomical Observatory of Belgrade (Milan S. Dimitrijević). It contains Stark line broadening parameters (widths and shifts) obtained within the impact approximation using the semiclassical perturbation approach [23,24].

These data are useful for modelling and spectroscopic diagnostics of stellar atmospheres and envelopes, as well as for laboratory plasmas, laser equipment, inertial fusion plasma and technological plasmas. So, the domain of temperatures and perturbing particle densities covered by the tables is wide and depends on the ionization degree of the considered ion. STARK-B [25] is currently developed in Paris, and a mirror site is under construction in Belgrade.

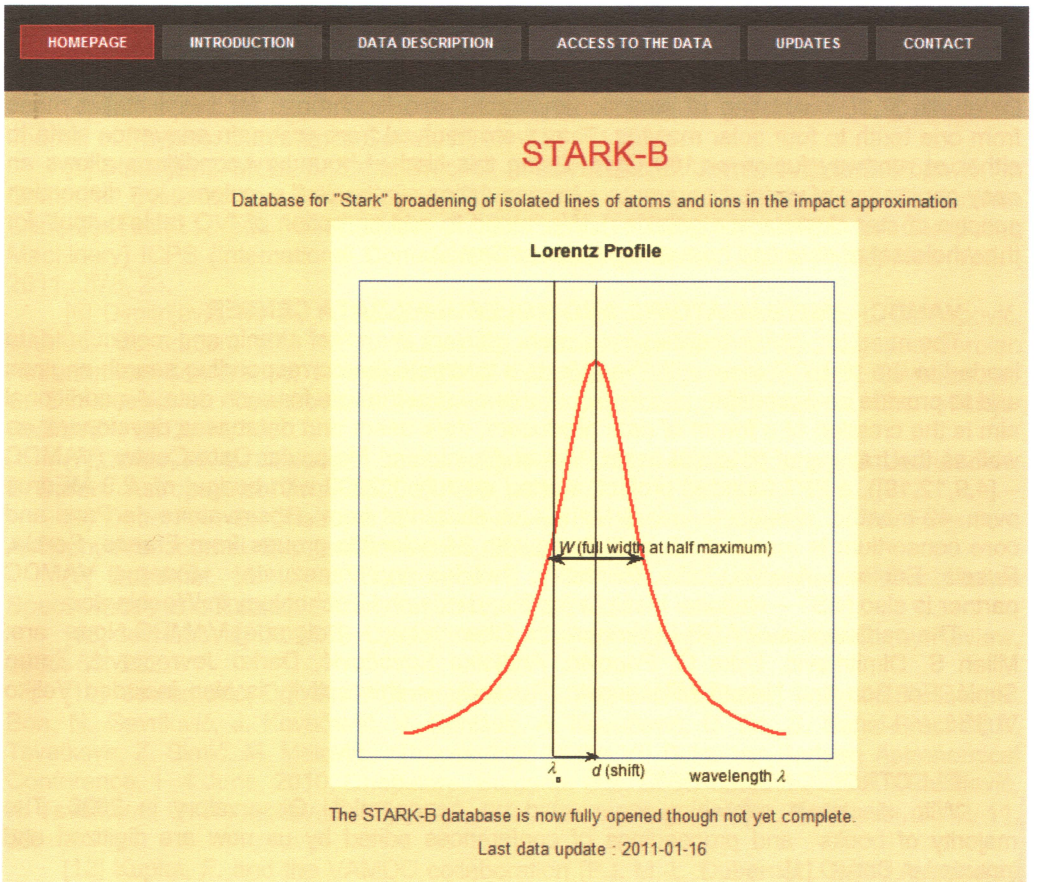

Fig. 4. The homepage of the STARK-B database

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. The simple graphical interface to the data is provided (see http://stark-b.obspm.fr/elements.php) . 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 table with shifts and widths is generated.

FUNDAMENTAL CATALOGUES

Actually, three fundamental stellar catalogues are digitized and included in SerVO: 1. CATALOGUE OF DECLINATIONS. THE LATITUDE PROGRAMME STARS (KŠZ) [22]; 2. CATALOGUE OF POSITIONS OF 223 ONDREJOV PZT STARS OBSERVED AT BELGRADE OBSERVATORY [20] and POSITION CATALOGUE OF 351 STARS SITUATED IN THE VICINITY OF RADIO SOURCES OBSERVED WITH THE BELGRADE MERIDIAN CIRCLE, [21].

DSED DATABASE

Darko Jevremović participated in the development of Dartmouth Stellar Evolution Database [7,8], consisting 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. 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.

VAMDC – VIRTUAL ATOMIC AND MOLECULAR DATA CENTER

The need to provide facilities for a more efficient search of atomic and molecular data leaded to the VAMDC Idea, with the objective to create the corresponding search engines and to provide an accessible and interoperable e-infrastructure for such data. An additional aim is the creation of a forum of data producers, data users and databases developers, as well as the training of potential users. Virtual Atomic and Molecular Data Center (VAMDC – [4,9,12,19]), a FP7 founded project, started on July 1 2009 with budget of 2.9 MEuros over 42 months. Project leader is Marie-Lise Dubernet from Observatoire de Paris and core consortium is made of 15 institutions with 24 scientific groups from France, Serbia, Russia, England, Austria, Italia, Germany, Sweden and Venezuela. External VAMDC partner is also NIST – National Institute for Standards and Technology in Washington.

The participants of AOB (Astronomical Observatory – Belgrade) VAMDC Node are: Milan S. Dimitrijević, Luka Č. Popović, Andjelka Kovačević, Darko Jevremović, Zoran Simić, Edi Bon and Nenad Milovanović. Recently, in this activity is also included Veljko Vujičić.

ELECTRONIC PUBLISHING

With electronic publishing we started on Astronomical Observatory in 2006. The majority of books and proceedings of conferences edited by us now are digitized and included in SerVO [1].

CONCLUSIONS AND FUTURE WORK

Work on SerVO is also in progress and we hope to enter soon in IVOA. We plan also to further develop and improve STARK-B database, and to enlarge and complete all mentioned collections of SerVO. We also plan to develop further the Serbian VAMDC node with an aim to become a regional center in South Eastern Europe.

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