Astroinformatics in Serbia – from small virtual observatory to involvement in LSST

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Abstract

In this contribution I review some aspects of development of the astroinformatics in Serbia. I pay special attention to the funding and educational challenges. As we recently joined the LSST project, we expect huge impact on Serbian science especially in the Big Data areas. Among others, our contribution will be in building simulator of alerts for the astronomical community and prototype of the CEP engine for analyzing data generated by the survey.

Overview of Astronomy in Serbia

There are two main institutions with significant number of astronomers in Serbia: Astronomical Observatory in Belgrade (AOB) and Department of Astronomy, Faculty of Mathematics, Belgrade University(DAFM). AOB employs about twenty researchers with PhD at different stages of their career and about fifteen PhD students. DAFM has about ten tenured/tenure track professors and about 15 Phd students. There are few astronomers at other institutions such as Institute of Physics Belgrade, Institute of Nuclear Sciences Vinča, Department of Physics University of Kragujevac, Department of Physics University of Niš, Department of Physics University of Novi Sad.

Funding of Astronomy (and generally science) in Serbia is grant based. Serbian Government currently funds the following eight projects:

- Astrophysical Spectroscopy of Extragalactic Objects (led by Luka Popović)
- Gravitation and the large scale structure of the Universe (Predrag Jovanović)
- Emission nebulae: structure and evolution (Dejan Urošević)
- Influence of collisions on astrophysical plasma spectra (Milan Dimitrijević, Zoran Simić)
- Stellar physics (Gojko Djurašević)
- Visible and Invisible Matter in Nearby Galaxies: Theory and Observations(Srdjan Samurović)
- Dynamics and kinematics of celestial bodies and systems (Zoran Knežević, Rade Pavlović)

- Astroinformatics: application of IT in astronomy and close fields (Darko Jevremović).

International collaboration

Astronomers from Serbia were and are involved in many internationally funded projects. The first European project we were involved was Virtual Atomic and Molecular Data Center[1] [2]. More details in section .

Project BELISSIMA (BELgrade Initiative for Space Science, Instrumentation and Modeling in Astrophysics) started in 2010. It is funded by European Comission under the FP7 REGPOT schema. The BELISSIMA will be concluded in June 2015. Main goals are:

- Reinforcement of the scientific potential of AOB (and, therefore, Serbian astronomical and space sciences) through increase of both width and depth of its overall research activities, observational and theoretical, as a consequence of "brain gain". This will be operational on several levels, in both theoretical and observational aspects of envisioned future research activity.
- Purchase, installation and testing of new observing equipement (telescope "Milanković" with1.5m-class mirror, to be installed on Astronomical Station Vidojevica
- Human potential, training and public outreach. Exchange of know-how and experience between EU research institutes and AOB. Training of AOB researchers in observational astronomy techniques and work towards establishing collaboration with other observatories in Europe and worldwide
- Popularization of Astronomy and Science

Stardust, the Asteroid and Space Debris Network, is an Advanced research network we participate in. One PhD student from Greece started his PhD thesis work at AOB in the September of the last year.

Astromundus is a master program in astrophysics. Five universities are involved - namelly Insbruck, Goettingen, Padova, Rome and Belgrade. Typicaly, 4-6 students attend classes in Belgrade during the fall semester of the second year of their course. Also, few students are doing their master thesis research in the final semester in Belgrade (either under our supervision or under joint supervision between two partners).

We actively participate in the following COST actions:

- MP0905 - Black Holes in a Violent Universe 24 March 2010 - 01 June 2014
- MP1104 | Polarization as a tool to study the Solar System and beyond | 21 November 2011 - 20 November 2015

- TD1308 Origins and evolution of life on Earth and in the Universe (ORIGINS) 15 May 2014 - 14 May 2018
- TD1403 Big data era in sky and Earth observations November 2014 - November 2018

Astroinformatics in Serbia

TR13022/2008 and III44002/2011

Small project TR13022/2008 "Serbian Virtual Observatory" was funded in years 2008-2010. This project was funded as technological developement project. The main goals of this project were digitization and publishing of old photo plates in Virtual Observatory, developement of BelData, Stark broadening database (it became StarkB database), contribution to Darthmouth Stellar Evolution Database and collection of other Serbain data. Idea was that all these would be accessible at http://servo.aob.rs Fig. 1

Figure 1: *The home page of the Serbian Virtual Observatory*

Other goal was a developement of services as one point contact with VO world, as well as installation and testing software for accessing difference astronomical and other databases.

From 2011 onwards, our activities in this field are supported through the interdisciplinary project III44002Astroinformatics: "Application of IT in Astronomy and Close Fields". Apart from continuing of efforts of the SerVO project, the goal of the project is to develop new services. The main goals are as follows.

History

In historical part of the project we are focused at:

- Digitization of certain number of photo plates from the AOB archive in SerVO
- organisatioin of database and services according to VO standards
- Digitisation of important astronomical works
- Publications of GAS are digitized and electronically available at

  http/servo.aob.rs/eeditions

High Performance Computing

In the last few years there is shift in HPC by using new technologies such as Graphical Processor Units (GPU). Of course this leads to new set of problems and paradigms for efficient usage of GPU. Paralelisation of existing codes is very different from message passing interface (MPI) or OpenMP paralelization.

We joined the bandwagon in 2010 by obtaining system system with 4 Tesla 1070 GPU units (every GPU 230 processors) through the grant from Alexander von Humboldt fondation. Towards the end of 2012 we obtained small server which consists of 12 nodes + master node. Each node comprises of 2x X5675 processor, 24Gb memory, 2Tb disk 2x M2090 Fermi GPU. Nodes are interconnected by Mellanox infiniband network. This system has theoretically $\sim 16TFlops$ double precision power ($\sim 10Tflops$ in practice).

The system is mainly used for the general stellar atmosphere code Phoenix runs. We did some adaptation and paralelisation using GPU (in collaboration with OU in Hamburg), mainly using GPU libs for solving matrix equations. Apart from that the system is used for Nbody simulations, SKIRTS – a dusty 3D radiative transfer code in AGN's. For another project 40% of SDSS DR9 images are transfered. We expect the rest to be available to us in the next few months.

VAMDC

The VAMDC was supported by EU in the framework of the FP7 "Research Infrastructures - INFRA-2008-1.2.2 - Scientific Data Infrastructures" initiative. AOB was one of 15 partners in the consortium via Stark B database. We are activelly involved in continuation of the project. We had and still have an active role in VAMDC - Consortium of Databases & Services Providers that has built a unified, secure, documented, flexible and interoperable e-science environment-based interface to its members atomic and molecular databases.

This project will in near future grow into Consortium of Atomic and Molecular databases very likely become European Research Infrastructure Consortium. Also we expect two new atomic and molecular databases to join the consortium.

Involvement in LSST

LSST is an optical- near infrared survey of half the sky in six bands (ugrizy') town to r$\sim$ 27.5 (36 nJy) based on thousand visits over ten year period. The 8.2 m telescope will be situated at Cerro Pachon in Chile on the close to Gemini South and SOAR telescope. The first light is expected in the year 2019 and the full survey will start in 2022.

We expressed our interest in involvement in LSST project in 2009. Through grant III44002 we applied for funding and it was granted from the EIB loan In November of 2013 we formally signed the Memorandum of Understanding with LSST Corporation. We have, so far, possibility to engage up to four PI's and their students and postdocs. Our interest is in variable phenomena, variable stars, AGN variability, gravitational micro-lensing, SNR & Planetary nebulae, Small solar system bodies (orbits, elements...), development of astroinformatics and development of algorithms, software... At the moment we appointed two PI's Luka Popović in AGN collaboration and Darko Jevremović in Transients and Variable stars collaboration.

As part of our contribution to the project we are developing simulator of alerts. More details about the requirements and strategies are given in [3].

Teaching astroinformatics at DAMF

Since 2011/2012 academic year DAMF offers course with a major in astroinformatics. There are several problems with this course. In essence, one really shoudn't just mechanically glue the Computer Science and Astronomy classes because:

Computer science classes + **Astronomy classes** $\neq$ **Astroinformatics**!!!

Other problem is that there is no introduction nor space to follow newest developement in the very dynamic field astroinformatics. Third problem the course

faces is lack of interested students. Namely, most of enrolled students are unsuccessful applicants in Computer Science course and after the first year they change their major accordingly. So, an opportunity to really change something in education of new generation of astronomers is missed.

Other activities

Our group has two stations for collecting ionospheric radio data. We are in the phase of obtaining new stations (fund are awarded). For this system data are collected in Stanford, and our contribution is in definition of standards as well as reorganization of databases.

Recently we launched a new service for fitting of FeII lines in AGN. Basically if you provide a AGN spectrum, we calculate 'best fit' and return fitted spectrum as well as physical parameters using method from [4]. Service is accessible at http://servo.aob.rs/FeII_AGN/

Concluding remarks

As seen from the above, Astroinformatics is an active and vibrant new research field in Serbia. We expect new opporunities to arise and that we put foundations for the next generation of astronomers to be able to do top level science in this exciting new field.

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References

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