

ASTRONOMY EDUCATION AND POPULARIZATION IN SERBIA

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Abstract. Astronomy education at all levels (elementary and secondary schools, universities) in Serbia is reviewed. The attempts to introduce astronomy as an elective course in elementary schools and to reintroduce astronomy as a separate subject in secondary schools are discussed. The role of the Petnica Science Center is briefly described, as well as the participation of the Serbian team in the International Astronomy Olympiads. A special emphasis is put on recent changes introduced in the accredited study programs at all five Serbian state universities. The research projects performed in two main astronomical institutions in Serbia are outlined. The numerous amateur astronomical societies in Serbia are presented and their growing activities summarized.

1. INTRODUCTION

Astronomy education and research in Serbia have tradition of almost 130 years. In this paper the most important activities are summarized that take place in Serbia in all five fundamental aspects of astronomy development: primary, secondary and tertiary education, research and science public outreach.

2. PRIMARY AND SECONDARY SCHOOLS

The beauty of the sky, the cosmic objects and the immensity of the Universe are inspirational for everyone, but especially for children. The Universe fascinates young children and stimulates their imagination. Due to this fact astronomy is one of the most attractive sciences and an excellent tool for introducing science and technology to children. Moreover, as the early years are crucial in the development of the human values system, the immensity of the Universe provides a perspective encouraging internationalism and tolerance.

In the elementary schools in Serbia astronomy topics are taught as part of the courses of Natural History, Geography and Physics. As astronomical studies have led to new discoveries in chemistry and biology and to the development of the new sciences of astrochemistry and astrobiology, astronomy topics could be integrated into the courses of chemistry and biology as well. Within the recent reform of primary school education, several astronomy lectures have been introduced as extra topics in the 7th

and 8th year physics course curricula. Since the science education at the younger age is crucial for developing scientific literacy among the general population and having in mind a unique role astronomy plays in facilitating education, astronomers in Serbia are trying to introduce astronomy as a separate and elective subject in the elementary school curricula.

In the secondary schools astronomy topics are incorporated within the final (4th) year physics courses. However, as the physics teachers often neglect astronomy topics, the astronomical community has made many efforts to reintroduce astronomy as a separate subject. Namely, for 25 years (1969-1994) astronomy was taught as a separate and compulsory course. However, in 1990 it was incorporated within the course of Physics. Since then astronomy is taught as a separate course only in the Mathematical High School of Belgrade and in a couple of high schools in Serbia.

2. 1. PETNICA SCIENCE CENTER

Petnica Science Center (PSC), located near Valjevo, some 100 km from Belgrade, is the biggest and the oldest center for extracurricular (informal) education in South Eastern Europe (<http://www.ispast.net>, <http://pi.petnica.rs>). Its main concept is *learning through research*. PSC programs give the gifted students an intensive extracurricular education and enable them to carry out scientific projects under the supervision of scientists and science teachers.

Since its foundation in 1982 Petnica has organized more than 2,500 programs (seminars, workshops, research camps, ...) for students and science teachers in 15 disciplines of science, technology and humanities. Majority of programs are designed for secondary-school students although there are a lot of programs for primary-school pupils, university students and science teachers.

The PSC organizes two cycles of seminars in astronomy consisting of 4 seminars per year. Each seminar is attended by about 25 participants and lasts 7-8 days on the average. The cycle "Astronomy 1" is of educational character as it is intended for the participants attending the PSC astronomy seminar for the first time. Participants of the second cycle "Astronomy 2" work on their independent observational/research projects, and the seminars of the second cycle are intended to support their work. The best research projects are presented at the Conferences of the PSC participants "A step into science" and published in "Petničke sveske" ("Petnica notebooks").

2. 2. INTERNATIONAL ASTRONOMY OLYMPIADS (IAO AND IOAA)

In 2002 Professor J. Milogradov-Turin (Milogradov-Turin 2003), then the president of the Society of Astronomers of Serbia (SAS), initiated the participation of Serbia in the International Astronomy Olympiad (IAO). Since 2004 the National Astronomical Olympic Committee (NAOC) has been in charge of training, testing and selection of the national team.

Serbian teams participate at two International astronomy olympiads: since 2002 at IAO (founded in Russia in 1996) and since 2007 at IOAA (International Olympiad on Astronomy and Astrophysics, founded on the initiative of Thailand, Indonesia, Iran, China and Poland in 2007). In the past 11 years Serbian teams (57 participants in

total) participated at 9 IAO and 4 IOAA olympiads and won 6 gold, 14 silver and 22 bronze medals, as well as 2 special prizes and 4 recognitions.

3. UNIVERSITY EDUCATION AND RESEARCH

Teaching of mathematics and physics in Serbia started in 1838 at Licej, which was transformed to Velika škola (the Grand School) in 1863. Astronomy teaching was introduced at the Grand School in 1884 when Milan Nedeljković, founder and the first director of the Astronomical and Meteorological Observatory of Belgrade, was elected professor for the courses of astronomy and meteorology. The Department of Astronomy now belongs to the Faculty of Mathematics of the University of Belgrade (for a detailed history of the Department/Chair of Astronomy see the review by Simovljević and Milogradov-Turin, 1998).

At present astronomy courses are taught at five state universities in Serbia: University of Belgrade, University of Novi Sad, University of Niš, University of Kragujevac and University of Priština in Kosovska Mitrovica. In 2005, the European Credit Transfer System (ECTS) is introduced and within the past three years the studies have been accredited at all state universities in Serbia.

Since the textbook "Nebeska mehanika" ("Celestial mechanics") written in 1935 by Professor Milutin Milanković, well known for his astronomical theory of climate, more than 20 university textbooks in astronomy and astrophysics written by professors of Serbian universities have been published.

3. 1. UNIVERSITY OF BELGRADE

At the University of Belgrade since early 1960's students can major in Astronomy and Astrophysics from the first study year. Apart from the courses in mathematics and physics they follow about 15 one-semester courses of astronomy and astrophysics. So far, 271 students have graduated from the Department of Astronomy, Faculty of Mathematics, University of Belgrade (46% of which are women), 69 students received MSc degree (39% women) and 41 students received PhD degree (27% women).

Since 2006/2007 academic year study programs of Astronomy and Astrophysics have been adjusted to the new ECTS. Model 4+1 for the first two degrees (bachelor in astronomy and master astronomer) was accepted. So far 18 students received master degree (61% women). In 2009/2010 the studies were accredited. New accredited study program "Astronomy and Astrophysics" consists of 3 programs (Computational mechanics and astrodynamics, Astrophysics, Astroinformatics) at undergraduate (4 years) level, 2 study programs (Astronomy, Astrophysics) at Master studies and one study program (Astronomy and Astrophysics) at PhD studies. Master programs contain 7+7 elective courses in astronomy and astrophysics, whereas 33 elective courses are offered at the PhD level.

Since 2011/2012 the Faculty of Mathematics participates in "AstroMundus", a 2-year master program in astronomy and astrophysics in the framework of the ERASMUS MUNDUS Programme of the EU (5 universities are included: Innsbruck (coordinator), Rome, Padova, Gottingen and Belgrade).

The Department of Astronomy organizes regular seminars on different topics in astronomy every second Tuesday during the academic year, the International summer schools in astronomy and astrophysics (2007, 2008, 2010) and Astronomy Students

Workshops (since 2007) together with the Department of Physics in Novi Sad and Astronomical Observatory in Belgrade, aimed at improving contacts between the students of astronomy from Belgrade and Novi Sad.

Apart from the above mentioned, at the Faculty of Mathematics astronomy is also taught either as compulsory course (for the students of mathematics and informatics teachers division) or as an elective course for all the students of Mathematics and Informatics. At the Faculty of Physics there is a compulsory one-semester course at master studies for physics teachers division, and an elective one-semester course for the students at undergraduate level. At the Faculty of Civil Engineering, a compulsory course of geodetic astronomy is taught.

3. 2. UNIVERSITY OF NOVI SAD

Since 2002/2003 academic year the Department of Physics of the Faculty of Natural Sciences at the University of Novi Sad has founded the astronomy study group, introducing simultaneously the European Credit Transfer System. First the model 3+1+1 was accepted. Since 2008/2009 new accredited studies are of the model 3+2. Up to now 18 students got 3-years diploma, 8 students got 4-years diploma and 3 students got master degree. Astronomy and astrophysics are also taught within one-semester elective courses to the students of other study programs at the Department of Physics.

3. 3. UNIVERSITIES OF KRAGUJEVAC, NIŠ AND KOSOVSKA MITROVICA

There are one-semester compulsory courses of astronomy for the students of physics at the Universities of Kragujevac, Niš and Kosovska Mitrovica, while several elective astronomy courses are taught at the Departments of Physics, Biology and Geography of the University of Niš.

3. 4. SUMMER PRACTICE / TRAINING IN OBSERVATIONS

Since 2007 the students of the Universities of Belgrade and Novi Sad have 3-weeks summer practice in observations and data reduction at the Ondrejov Observatory (Czech Republic). The students are included in research at the following four departments: Stellar department (physics of hot stars), Solar physics department (solar flares and prominences), Department for interplanetary matter (asteroids) and Department for galaxies and planetary systems. As of recently they are using also the facilities (60 cm reflector) of the Astronomical Station at mountain Vidojevica.

3. 5. RESEARCH IN ASTRONOMY

Astronomy research in Serbia is mainly performed in two astronomical institutions: Astronomical Observatory of Belgrade (AOB, founded in 1887, 42 researchers) and the Department of Astronomy, Faculty of Mathematics, University of Belgrade (15 researchers). With researchers from the Institutes of Physics (Zemun and Vinča), Universities of Novi Sad, Kragujevac and Niš, there are about 70 researchers in astronomy in Serbia and about as many in abroad. The researchers participate in 9 scientific projects financed by the Ministry of Education and Science of Serbia and in several international cooperations and projects (SREAC, VAMDC, Belissima, Astromundus, LSST). The researchers of the Astronomical Observatory participate in the undergraduate study programs at the University of Novi Sad, as well as in the Master and PhD study programs of Astronomy and Astrophysics at the Belgrade University.

Main research topics are: (a) Astrometry and dynamical astronomy: Earth rotation, Solar system dynamics, Celestial mechanics, Double stars, Stellar systems dynamics; (b) Astrophysics: Astrophysical spectroscopy, Solar physics, Radiative transfer, Close binary stars, Stellar kinematics and dynamics, Interstellar medium, Supernova remnants, Galactic astronomy, Extragalactic astronomy (AGN, gravitational lensing), Cosmology; (c) Astrobiology; (d) Astroinformatics and (e) History of astronomy. For more on the history of AOB and of its research activities see Atanacković-Vukmanović (2007).

The largest telescope in Serbia is still a refractor Zeiss 650/10550 mm at AOB. Purchase of a 1.5m class telescope is in progress. It will be mounted at the same site as 60 cm telescope on Vidojevica mountain in the next couple of years.

The Astronomical Observatory and the Department of Astronomy publish together *Serbian Astronomical Journal* (<http://saj.matf.bg.ac.rs>). Also, every three years these two institutions organize National conferences of astronomers of Serbia (NCAS) with more than 100 participants and about 10 guests from abroad. The proceedings of the Conference are published in the *Publications of the Astronomical Observatory of Belgrade*.

4. PUBLIC OUTREACH

Astronomy is the most attractive of all sciences for the general public. As a unique combination of science, technology and culture, astronomy continues to play an important role in modern society. In Serbia it receives much more attention in the newspapers and other media than the other sciences. Yet, public astronomy education in Serbia is mainly realized through various activities (public observations of astronomical events, lectures to elementary/secondary school students and the general public in two Planetaria (Belgrade and Novi Sad), courses, conferences, schools and camps) of 20 amateur astronomical societies (see Table 2 in Atanacković, 2012).

In January 2010 the Association of astronomical societies and astronomical sections of Vojvodina was founded. Also, the Amateur Astronomers Association of Serbia (SAAS, <http://www.saasr.org>) was founded in February 2010 with the aim to include all astronomical societies in Serbia in popularizing astronomy and related sciences by organizing camps, lectures, observations etc. all over Serbia. A nice example of an intensive collaboration among the amateur societies is Letenka camp organized every year on the mountain Fruška gora.

The common problem of all amateur societies is lack of adequate space, equipment and financial support. They usually manage to survive thanks to enormous enthusiasm and the hard work of their members, often consisting of only a few people.

Many amateur astronomical societies have their web sites. More details about their activities can be found in the journals/magazines they publish: *Vasiona* (*The Universe*, since 1952); *Astronomija* (2003-2009); the internet magazine "Astronomical magazine" - the largest astronomical web site (<http://www.astronomija.co.rs>) in the country, maintained by the AS "Lyra" of Novi Sad since 1998; annual bulletins *Gea*, etc.

The societies took part in the popularization of astronomy through local TV and radio programs, newspapers and web portals. They participate in some special events (Night of Museums, at national and international conferences, Book Fairs, Education

Fair "Bell", Festivals of Science, International Year of Astronomy etc.). Majority of societies organize regular courses/schools of astronomy for the beginners.

The most popular events organized by astronomical societies in Serbia are:

- *Belgrade Astronomical Weekends* and *Summer Astronomical Meetings* organized by the largest and the oldest society of amateur astronomers - AS "Rudjer Bošković" situated within the Kalemegdan fortress in Belgrade; the Society organizes also Summer Schools of Astronomy often together with other astronomical societies;

- *international astronomical camps "Letenka"* lasting four days in July and observation competition in *the Messier marathon* early in spring at Letenka, both organized by AS "Lira";

- *Astronomical Meetings of Vršac* (Astronomical Group of "Gea" Society);

- *Niš astronomical meetings* (AS "Alfa");

- the exhibitions of astrophotographs (AS "Univerzum");

- astronomical camps in Sivčina near Ivanjica (AS "Orion"), and in Deliblatska peščara (AS "Milutin Milanković", Pančevo).

More details about the recent activities of the amateur astronomical societies can be found in Atanacković (2012).

5. CONCLUDING REMARKS

Serbia is an IAU member state with 41 individual members. According to the classification scheme given in the IAU Strategic Plan, Serbia belongs to the Group 1B of developed astronomy research countries with fewer than 4 members per million inhabitants, that participate in, or host, frontline astronomy research facilities. It is also the country with high education index of about 0.8 (education index is $E = (2/3)L + (1/3)C$, where L is literacy rate and C is combined gross school enrolment ratio).

The main goals in astronomy education and popularization in Serbia are the following:

- reintroduction of astronomy as a separate subject in the school curricula

- education of teachers through courses, seminars and workshops

- training best pupils for the astronomical olympiads

- strengthening of relations with other universities in the SEE region and worldwide (twinning between universities), and

- intensification of the public education in astronomy via lectures, articles, radio and TV programs.

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