

ASTRONOMY EDUCATION IN SERBIA 2011-2014

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Abstract. A triennial review is given on astronomy education in Serbia at all levels (primary and secondary schools, and universities), on astronomy programmes of the Petnica Science Center, on the activities of amateur astronomical societies, and on the participation of the Serbian team in the International Astronomy Olympiads.

In this paper astronomy education in Serbia with an emphasis on the changes that occurred in the period from 1 November 2011 to 1 November 2014 is described. The previous period was covered in the papers by Atanacković (2009, 2012), Atanacković-Vukmanović (2006a,b) and by Milogradov-Turin (2002) and in the references therein.

1. PRIMARY SCHOOLS

In the elementary school curricula astronomy topics are taught as part of the courses of Natural History (IV), Geography (V) and Physics (VII and VIII year). Apart from the obligatory program, additional astronomical topics are taught as part of the activity of astronomy clubs organized by the enthusiastic teachers of physics, mathematics or geography in some primary schools. During the Conference we had a nice opportunity to learn about such kind of activities in two primary schools: "Jelica Milovanović" from Sopot and "Vasa Živković" from Pančevo (see the papers by Maričić - Mirilović et al. and Krstin in this volume).

2. SECONDARY SCHOOLS

It is worth remembering that after 25 years (from 1969 to 1994) of being a separate and compulsory fourth year one hour per week course, in 1990 astronomy topics became incorporated in the final (fourth) year physics courses. Since then, and especially during these past three years, attempts have been made to reintroduce astronomy as a separate (either compulsory or elective subject), but still without success.

New standards for teaching of Physics are introduced in the framework of the reform of the secondary schools education. Unfortunately, also in these reformed standards astronomy is still regarded as a part of Physics.

At regular annual meetings of physics teachers organized by the Serbian Physical Society, only one lecture on the topics related to astronomy, "European extreme large telescopes" (Ilić 2014), was given in the previous period.

The first School of Astronomy organized by the students of the Department of Astronomy of the Faculty of Mathematics in Belgrade was held in May and June 2014 (twice per week) in Dom omladine, Belgrade. It is intended for the young people (from 15 to 25 of age) and mainly for the secondary school students. In the 2014/2015 academic year the lectures are planned to be given during both semesters.

2. 1. PETNICA SCIENCE CENTER (PSC)

The reconstruction and modernization of Petnica Science Center, the biggest and the oldest center for extracurricular (informal) education in SE Europe, lasted from 2011 to 2013. The purchase procedure for new astronomical equipment, including 60cm telescope is in progress. The telescope is to be mounted at the new Observatory, which should be built on a hill above the PSC.

In the past three years the Program of Astronomy in PSC included 17 seminars for secondary school students interested in astronomy and involved 150 participants in total. About 35 researchers from the University, Astronomical Observatory and other institutes, as well as the students of astronomy, took part in their realization (Božić, 2014). The two cycles of seminars in astronomy organized by the PSC are described in more detail in Atanacković (2009). About 35 individual research projects were realized by the participants of the seminars that belong to the most advanced group. Twenty one of them (Andjelković, S., Vranješ, G., 2011; Arsovska A., 2014; Blagojević, M., 2014; Bogdanović, A., Rajić, M., 2013; Djošović, V., Ratković, J., 2014; Fuks S., 2014; Jovanović, M., 2011; Kabić, J., 2011; Majić, B., 2013; Marković, S., 2012; Milošević, A., Janješ, A., 2011; Mirković, S., 2011; Perić, D., 2014; Reljić, A., 2011; Stojanović, N., 2013; Šarković, V., 2012; Šarković, V., Živanović, F., 2011; Vukadinović, D., 2012; Vukadinović, D., Šarković, V., 2013; Vukadinović, D., 2014; Živadinović, L., 2014) were presented at the annual conferences "A step into science" (in December) and published in four volumes (68, 69, 70 and 72) of "Petničke sveske" ("Petnica notebooks").

The first summer school for students, "Petnica Summer Institute", was held in August 2013. It was devoted to Cosmology. In 2014 the summer school was dedicated to Particle Physics. About 40 students participated, while 15 lecturers from SISSA, ETH, AOB and Petnica took part in their realization.

The 9th and 10th Petnica International Science Summer School was held in August 2013 and 2014. Participants from Japan, Russia, Poland, Romania, Spain, Bosnia and Hercegovina, Turkey, Greece and Serbia worked on 6 different scientific student projects in the fields of astronomy, physics & computer science, biology & chemistry and anthropology.

More details on the activities of PSC can be found at: <http://www.psc.ac.rs>.

2. 2. INTERNATIONAL ASTRONOMY OLYMPIADS

In the past three years (2012-2014) Serbian teams participated in the IOAA (International Olympiad on Astronomy and Astrophysics) and won 3 gold, 3 silver and 3 bronze medals in total, as well as 4 recognitions (Ninković, 2014; Vidojević et al. in this volume).

Let us recall that in 2002 Professor J. Milogradov-Turin (Milogradov-Turin 2003), then president of the Society of Astronomers of Serbia (SAS), initiated the participation of Serbia in the International Astronomical Olympiads. Since then Serbian teams won 9 gold, 16 silver and 24 bronze medals, as well as 2 special prizes and 7 recognitions in total.

3. UNIVERSITY EDUCATION

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).

The University of Belgrade is still the only university with the Department of Astronomy (at the Faculty of Mathematics - FM). Students can major in astronomy from the first study year.

So far 278 students have graduated from the Department of Astronomy at the University of Belgrade, 25 students received Master degree, 69 students received MSc degree and 47 students - PhD degree. In the past three years, 13 students graduated, 13 students got master and 9 PhD degree.

The studies were performed according to the programs accredited in 2009/2010. The study program "Astronomy and astrophysics" consisted of 3 modules (Computational mechanics and astrodynamics, Astrophysics, Astroinformatics) at undergraduate level, 2 modules (Astronomy, Astrophysics) at Master level and one module (Astronomy and Astrophysics) at PhD level. New study programs are accredited at the end of 2014, and will be introduced in 2015/2016. The study program "Astronomy and astrophysics" will consist of 2 modules (Astrophysics, Astroinformatics) at undergraduate and Master levels, and will be one module at PhD level as before. Moreover, within the study program "Mathematics" there will be module "Astronomy" at undergraduate level, and module "Astronomy and Mechanics" at Master level.

Since 2011/2012 the Faculty of Mathematics of the University of Belgrade participates in "AstroMundus", a 2-year European Erasmus Mundus Joint Master program in astronomy and astrophysics of 5 universities: Innsbruck (coordinator), Rome 2, Padova, Göttingen and Belgrade (see website www.astromundus.eu). The University of Belgrade (Faculty of Mathematics) offers the 3rd and the 4th semester of the Master program. Since then, there were 4 classes of students (school years 2011/2012 - 2014/2015). Twenty students in total visited and were enrolled at the Faculty of Mathematics from all over the world (16 countries: Mexico, Spain, Italy, Pakistan, India, Macedonia, Georgia, Columbia, Peru, Turkey, Chile, Venezuela, Croatia, USA, UK, Slovenia), out of which 3 students defended the Master thesis in Belgrade (2011/2012). In the first year of AstroMundus program, the Best Master thesis award was given to the student that defended the thesis in Belgrade. Additionally, there were 4 joint Master theses, two theses defended at the University of Innsbruck (2012/2013) and two at the University of Göttingen (2013/2014) (Ilić, 2014).

The students of the Department of Astronomy continued with the training in observations and data reduction at the Ondřejov Observatory (since 2007 they have 3-weeks summer practice there). Since 2012 three summer practices lasting 3-5 days

(June 2012, July 2013, October 2014) have been organized at the Astronomical Station on the mountain Vidojevica. Some 12 students from Belgrade and Novi Sad participated in this practice each year.

The Department of Astronomy continued to organize regular seminars on different topics in astronomy on every second Tuesday throughout the academic year, so that 43 seminars have been held in this triennial period. Eighteen seminars were also held at the Astronomical Observatory in Belgrade.

The Astronomy Students Workshops (ASWs) have been organized since 2007 at different locations by the Department of Astronomy in Belgrade, 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 and giving them an opportunity to present their work (seminars, master/PhD thesis research, and summer practice). The 5th ASW was held in November 2011 at the Public Observatory of the AS "Rudjer Bošković" in Belgrade, the 6th ASW in April 2013 at the Department of Physics in Novi Sad (23 students), and the 7th ASW in April 2014 at the Society "Milutin Milanković" in Belgrade (39 students). The ASWs are growing in popularity among students.

At the Faculty of Mathematics astronomy is also taught as a compulsory course "Introduction to astronomy" (3rd study year) for the students of L division (mathematics and informatics teachers), as an elective course "Selected topics in astronomy" (4th year) for all modules of the study program "Mathematics" and in two elective courses "Stellar astronomy" and "Ephemeris astronomy" (1st/2nd year) for the students of the study program "Informatics".

At the Faculty of Physics astronomy is taught as a compulsory one-semester course "Fundamentals of astrophysics" at the 1st year of master studies for physics teachers division, and as an optional one-semester course under the same name for the students of the 1st year of B (theoretical) and C (applied) division, and for the students of the 2nd or the 3rd year of A (general) division. In the past three school years, on average 25 students per year selected this course.

At the Faculty of Civil Engineering, a compulsory course "Geodetic astronomy" (4th year) is taught. At the Faculty of Geography, basic astronomical topics are taught within the first-year course (2+1) "Mathematical Geography" for the students of General division and Geography teachers division. Visits to the Planetarium and to the Astronomical Observatory, Belgrade are compulsory (Tadić, 2014).

New accredited studies at the Astronomy study group, founded in the 2002/2003 academic year at the Department of Physics of the Faculty of Natural Sciences (FNS) at **the University of Novi Sad** are of the model 4+1 (firstly, the model was 3+1+1, and then 3+2 in 2008/2009).

In the past three years 23 students enrolled astronomy studies at the Faculty of Natural Sciences in Novi Sad. Six students graduated and four students received the Master degree (Prodanović 2014).

At the Department of Geography of the FNS in Novi Sad, a course "Mathematical geography with the fundamentals of astronomy" (3+2) is taught in the first study year (Tadić, 2014).

At the Institute of Physics of the Faculty of Natural Sciences of **the University of Kragujevac** there is a one-semester (2+2) elective course, "Astrophysics and Astronomy", for the 5th-year students of Physics. The students use equipment (a

Carl Zeiss Telescope 150/2250 and a 200/1000 Newton telescope) of the Astronomical Observatory that belongs to the Faculty (Simić, 2014).

At the Department of Physics at the Faculty of Natural Sciences (FNS) of **the University of Niš**, an elective course "Introduction to Cosmology" is taught at the 3rd study year of undergraduate studies. At Master studies, a compulsory course "Fundamentals of Astrophysics" (2nd year) for the students of General Physics is taught. The same course is elective for the master students (1st year) of Physics - Informatics. At the PhD level, there are two elective courses: "Cosmic plasma" and "Fundamentals of cosmology" (Gajić, 2014).

At the Department of Biology, an optional course "Fundamentals of astrophysics with astrobiology" is taught at the first study year of Master studies. At the Department of Geography, an elective course "Astronomy" is offered to the first-year master students (Gajić, 2014). At the Department of Geography, a course "Mathematical geography" (2+2) includes some basic astronomical topics (Tadić, 2014).

Thanks to the Project "Armchair Astronomy" a dome is installed on the roof of the Faculty, Lunt telescope LS60T with H α filter for the solar observations and the Mead Color CCD camera are bought for the students' exercises and popularization of astronomy (Gajić, 2014).

At the **University of Priština in Kosovska Mitrovica** a one-semester 2-hour per week course, "Fundamentals of astronomy and astrophysics", is taught to the second year students of physics.

At the Department of Geography at the FNS in Kosovska Mitrovica, a course "Mathematical geography" (2+2) includes some astronomical topics (Tadić, 2014).

In 2013, a new university textbook "Stellar Astronomy" by Trajko Angelov was published (edited by the Faculty of Mathematics, Belgrade).

3. 1. RESEARCH IN ASTRONOMY

Astronomy research in Serbia is mainly performed at the Astronomical Observatory in Belgrade (42 researchers) and at the Department of Astronomy, Faculty of Mathematics, University of Belgrade (11 professors+assistants + 4 PhD students). With the Institutes of Physics (Zemun and Vinca), University of Novi Sad, Kragujevac and Niš, there are about 70 researchers in astronomy in Serbia and about as many abroad. They participate in 8 national scientific projects and several international cooperations and projects (SREAC, VAMDC, Belissima, Astromundus, LSST, Stardust, Pavle Savić). The researchers of the Astronomical Observatory participated in the study programs at the Universities of Belgrade and Novi Sad.

The big news is that as of 2014 Serbian Astronomical Journal entered the SCI list (see Knežević et al. in this volume).

Let us mention here also that ADICT - an interactive English-Serbian astronomical dictionary/website is installed in January 2014 with the intention to help both the professional astronomers and non-professionals in writing and/or translating the scientific and popular papers (see Arbutina and Momić, in this volume).

4. PUBLIC EDUCATION

Public astronomy education in Serbia was realized mainly through the activities of 23 amateur astronomical societies (Table 1). In the past three years, three amateur

societies were founded ("Vega" in Surdulica, "Kraljevo" in Kraljevo, and "Tycho Brahe" in Belgrade). Let us mention here that the AS "Tycho Brahe" in Belgrade, which is mainly doing astrophotography (they use Newton telescope 150/750 and German equatorial amount EQ3) won the special recognition for the best poster during the XVII National Conference of Astronomers of Serbia.

Amateur astronomers association of Serbia (Savez astronoma amatera Srbije - SAAS, www.saasr.org) founded in February 2010, now contains seven registered societies (AS "Orion" Ivanjica, AS "Andromeda" Knjaževac, AS "Aristarh", Kragujevac, AS "Novi Pazar" Novi Pazar, "Magelanov oblak", Prokuplje, "Vlasina", Vlasotinci, "Gea", Vršac).

In 2014 the AS "Rudjer Bošković" (Belgrade) celebrated 80 years of the Society, 60 years of the Public Observatory and 45 years of the Planetarium (Aleksić, J. and Stanić, N., 2014). The AS "ADNOS" (Novi Sad) celebrated 40 years of its foundation.

Many societies have a collaboration with schools and other institutions in their cities and many contacts with other astronomical societies in Serbia and in neighboring countries. A nice example of an intensive collaboration among the amateur astronomical societies in Serbia and professional astronomers is the international astronomical camp "Letenka", one of the biggest camps for the popularization of astronomy in Europe. It has been organized since 2001 every year in July (lasting four days) on the mountain of Fruška gora. This camp includes lectures, observation competition, and astronomy related documentaries. About 200 people (mostly secondary school and university students) take part in "Letenka". Also, the AS "Lira", AS "Univerzum" and AS "Novi Sad" organize the observation competition in the Messier marathon (Mm) every year (early in spring) at Letenka. For much more details on these joint activities of the amateur astronomical societies in Serbia, and on some of the joint public observations see the paper by Zorkić in this volume. For more information on the activities of the astronomical societies see their websites that are given in Table 1, the Astronomical Magazine (AM) website, the largest astronomical web site in the country, the astronomical review "Vasiona" (published by AS "Rudjer Bošković", Belgrade), the annual bulletins "Gea" (published by Astronomical group within the Natural History Society "Gea", Vršac), and the most recent contributed papers by Tomić, Janković et al., Jeremić, Milovanović et al., Aleksić and Stanić (this volume). Their usual activities and equipment are described in detail also in the paper by Atanacković (2012).

Since 2011 the AS "Univerzum", Bačka Palanka, possesses the robotized astronomical observatory they built by themselves. They observed tens of variable stars, and discovered one eclipsing binary, which is in the database of AAVSO (American Association of Variable Star Observers). They also detected 96 transits of extrasolar planets that are registered in "Extrasolar transit database". They took photographs of several supernovae, hundreds of galaxies, asteroids, comets, stellar clusters, and began to work on the photometry of asteroids. They exchange the data obtained by means of camera for detecting meteors with Croatian meteors network (Mravik, 2014).

The societies continued their usual activities. "Astronomy courses for beginners" (one at each autumn and spring), Belgrade astronomical weekends (BAW), Summer Schools of Astronomy, as well as a special topical meetings "Summer Astronomical Meetings" have been organized by AS "Rudjer Bošković", Astronomical Meetings of

Vršac (AMV) by the Astronomical group within the Natural History Society "Gea", Autumn and Spring Schools of Astronomy by the AS "Andromeda" (Knjaževac), and astronomical camps in Sivčina by the AS "Orion" (Ivanjica). Most of the societies participated in special events (Night of Museums, Book Fair, Festival of Science, Night of Researchers, etc.).

Many lectures have been also given in Dom omladine, as well as in the Students' Cultural Center in Belgrade.

In the past five years (2009-2014) Astronomical Society "Rudjer Boskovic" and Society of Astronomers of Serbia used the mobile planetarium as a tool for astronomy communication. During the 2013/2014 school year this equipment has been used in schools as an educational tool (for details see Stanić et al. in this volume).

Let us recall that astronomy has also been popularized by the "Mladi fizičar" ("Young Physicist"), a quarterly magazine for the elementary and secondary school students.

Table 1. Amateur astronomical societies in Serbia; AS - Astronomical Society, AG - Astronomical Group, SRAR - Society for Radio-astronomy Research

No.	name	year	town	website
1	AS "Rudjer Bošković"	1934	Belgrade	adrb.org
2	AG of the "Vladimir Mandić-Manda"	1973	Valjevo	istrazivaci.rs/
3	AS "Novi Sad" (ADNOS)	1974	Novi Sad	adnos.org.
4	AS "Alfa"	1996	Niš	alfa.org.rs
5	AS "Milutin Milanković"	1996	Zrenjanin	www.admm.edu.rs
6	AS "Lira"	1998	Novi Sad	astronomija.co.rs
7	AG within "Gea"	1999	Vršac	gea.org.rs
8	SRAR "Aurora"	2000	Bor	
9	AS "Magellanic Cloud"	2001	Prokuplje	
10	AS "Andromeda"	2003	Knjaževac	andromedaknj.wordpress.com
11	AS "Novi Pazar"	2004	Novi Pazar	
12	AS "Tesla"	2004	Belgrade	
13	AS "Univerzum"	2006	Bačka Palanka	univerzumad.com
14	AS "Orion"	2007	Ivanjica	
15	AS "Milutin Milanković"	2007	Pančevo	aumm.yolasite.com
16	AS "Aristarh"	2007	Kragujevac	
17	AS "Eureka"	2010	Kruševac	eureka.nebjak.net
18	AS "Bor"	2011	Bor	adbtor.wordpress.com
19	AS "Kasiopeja"	2011	Leskovac	
20	AS "Vlasina"	2011	Vlasotinci	
21	AS "Vega"	2012	Surdulica	vega.edu.rs
22	AS "Kraljevo"	2012	Kraljevo	
23	AS "Tycho Brahe"	2010	Belgrade	aadtychobrahe.blogspot.com

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The vision of education reform in Serbia has been directed towards the creation of an education system: capable of gathering and including significant actors and answering to their real needs; decentralized, efficient, effective, and transparent; employing highly professional, reflexive, creative and motivated education staff; offering a high quality curriculum; promoting the culture of evaluation, self-evaluation, and school development; nurturing fairness, tolerance, and.Â The following optional subjects are also available for students in Form 4: astronomy; descriptive geometry; art; music; history of art; pedagogy; developmental psychology; ethics; drama; demography; geology; classical Greek; general linguistics. According to legislation, a student can have four optional lessons per week. There is a relative long and occasionally dissonant teaching of Astronomy in Serbia. The history of this theme is discussed in details. We read about "ups" and "downs" of astronomy in the literature and about possible historical reasons for this. We see that it is important for astronomers to be included in broad curriculum planning. We also discuss current projects to improve our elementary schools with virtual teaching of astronomy and high school astronomy science teaching via a virtual system of classrooms and observatories. The general aspects of the school system are activating the astronomy education in the junior classes of the high school; promoting extracurricular activities in amateur clubs, scientific societies, circles etc.; stimulating organization of national astronomical Olympiads in different countries; enhancing international contacts in the field of astronomy and physics education in schools. 3) Stimulating the imagination and creativity of children: the character of the astronomical tasks enables putting the students in non-standard situations, very close to those of a real scientific research; they can require creating hypotheses, assuming a