

ASTRONOMY EDUCATION IN SERBIA 2014-2017

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Abstract. A triennial review is given on astronomy education in Serbia at all levels: primary and secondary schools, and universities. Emphasis is put on the activities of the Petnica Science Center, the participation of the Serbian team in the International Astronomy Olympiads, newly accredited study programs, the School of Astronomy organized by the students of the Department of Astronomy (Faculty of Mathematics, University of Belgrade), the Astronomical Student Workshops, as well as on the activities of numerous amateur astronomical societies.

The changes in astronomy education in Serbia that occurred in the period from 1 November 2014 to 1 November 2017 are described in this paper. The previous period was covered in the papers by Atanacković (2009, 2012, 2017), Atanacković-Vukmanović (2006a,b) and Milogradov-Turin (2002), and in the references therein.

1. PRIMARY SCHOOLS

Astronomy topics in the elementary school curricula are mostly taught as part of the courses of Geography (V). Having in mind the importance of astronomy education at early age and an increasing interest of pupils in astronomy, in 2015 the Department of Astronomy, Faculty of Mathematics, University of Belgrade, has undertaken the first activities in the introduction of Astronomy as a separate elective course in the elementary schools.

2. SECONDARY SCHOOLS

We should recall again that after 25 years (from 1969 to 1994) of being a separate and compulsory, one hour per week, course in the fourth year of the secondary schools, in 1990 astronomy topics became incorporated in the final (fourth) year physics course. Only a few special schools in Serbia (e.g. Mathematical High School in Belgrade, "Jovan Jovanović Zmaj" in Novi Sad, "Svetozar Marković" in Niš) have astronomy as a separate subject. Numerous attempts made to reintroduce astronomy as a separate subject still remained with no success. New standards for teaching of Physics were introduced in the framework of the reform of the secondary school education in 2014, but, unfortunately, astronomy is still regarded as a part of Physics.

At regular annual meeting of physics teachers organized by the Serbian Physical Society that was held in 2017 in Šabac, prof. Tijana Prodanović gave a talk "Teacher

as a science communicator”, stressing the fact that teachers in Physics have to be acquainted with the discoveries and news in astronomy.

An extremely small part of the primary and secondary schools curricula in Serbia is devoted to astronomy. Astronomical community has been trying to compensate for this lack by means of three very important extracurricular activities: (a) the activities of the Department of Astronomy in Petnica Science Center, (b) the activities of National Astronomical Olympic Committee (NAOC) in training the Serbian team for participation at the International Astronomy olympiad and (c) the School of Astronomy organized by the students of the Department of Astronomy of the Faculty of Mathematics in Belgrade.

The new textbook ”Astronomy” for the 4th year of secondary schools, written by Olga Atanacković, is published in 2016 by Klett.

2. 1. PETNICA SCIENCE CENTER (PSC)

The activities of Petnica Science Center are very important in additional, extracurricular astronomy education of the gifted secondary-school students.

In the past three years the Program of Astronomy in PSC included 21 seminars for secondary school students interested in astronomy and involved 153 participants in total. Twenty eight researchers from the Department of Astronomy at Belgrade University, Astronomical Observatory Belgrade and other institutes, as well as 18 students of astronomy, physics and electrical engineering took part in their realization (Božić, 2017). The two cycles of seminars in astronomy organized by the PSC are described in more detail in Atanacković (2009) and in the paper by Bošković et al. (2018, this volume). Twenty individual research projects were realized by 26 participants of the seminars that belong to the most advanced group. They were presented at the annual conferences ”A step into science” (in December) and published in ”Petnica notebooks” (Vukadinović, 2017).

Petnica Summer Institute (PSI) - an annual international summer school for undergraduate and early graduate students has been organized since 2013 by a group of senior associates of the Department of Astronomy at PSC. It covers topics in theoretical (astro)physics that change in a four year cycle (cosmology, high energy physics, astrophysics and astroparticle physics and general relativity). In the past three years three summer schools were held: the 3rd Summer School on Astrophysics and Astroparticles in 2015, the 4th Summer School on General Relativity in 2016 and the 5th Summer School on Cosmology in 2017. Lecturers are mainly senior PhD students and postdoc researchers. The organizers are Petnica Science Center, ICTP (Trieste), SISSA (Trieste), CERN (Geneva), ETH (Zurich), University of Nova Gorica (Slovenija), Princeton University (US).

More details on activities of PSC can be found in the paper by Bošković et al. (2018) and at: <http://www.psc.ac.rs>.

2. 2. INTERNATIONAL ASTRONOMY OLYMPIADS

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 partic-

ipation of Serbia in the International Astronomy Olympiads. Since then Serbian teams won 10 gold, 22 silver and 34 bronze medals, as well as 2 special prizes and 15 honorable mentions in total (Vidojević et al. 2017, 2018).

In the past three years (2015-2017) Serbian teams participated at the IOAA (International Olympiad on Astronomy and Astrophysics) and won 3 silver and 9 bronze medals in total, as well as 7 honorable mentions.

Since 2013 Serbia participates in the Saint-Petersburg Astronomical Olympiad, which represents the correspondence type competition. Since then Serbia won 1 gold, 3 silver and 1 bronze medals, as well as 1 honorable mention (Vidojević et al. 2018).

Two books that have been used in preparations for astronomy olympiad are translated by Sonja Vidojević and published by the Society of Astronomers of Serbia in 2014 and 2017 (Vidojević, 2014, 2017).

In 2013, at the 7th IOAA, Serbia was nominated as the host for 15th IOAA in 2021. In November 2017 the Minister of Education, Science and Technological Development of the Republic of Serbia, Mr. Šarčević, addressed a letter to the President of IOAA informing that the Ministry will participate in organization and hosting of the 15th IOAA in 2021 (see Fig. 1 in the paper by Vidojević et al. 2018).

2. 3. SCHOOL OF ASTRONOMY

Since May 2014 the students of the Department of Astronomy of the Faculty of Mathematics in Belgrade have organized four Schools of Astronomy for young people (age 15 to 25), mainly for high school students. Two-hour lectures have been given twice a week. The 1st School was held in May and June 2014 (16 lectures, 5 workshops, 30 participants), the 2nd in October-December 2014 (15 lectures, 5 workshops, 35 participants), the 3rd in April-June 2015 (12 lectures, 3 workshops, 47 participants), and the 4th in November-December 2016 and April-June 2017 (18 lectures, 5 workshops, 40 participants). Each lecture is given by a pair of students (junior and senior). The lectures were held in "Dom omladine" (the first two schools), Belgrade and in the Society "Milutin Milankovic", Belgrade. The last School was supported by the CPN (Center for the promotion of science) as one of the top ten independent scientific-popular projects and by ESO (Šarković, 2017).

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).

At the Department of Astronomy, Faculty of Mathematics, **The University of Belgrade** (UB) since early 1960's students can major in Astronomy and Astrophysics from the first study year. So far 297 students have graduated from the Department of Astronomy at the University of Belgrade (since 1936), 36 students received Master degree (since 2007), 69 students received MSc degree (1968-2010), and 56 students - PhD degree (since 1958). In the past three years, 18 students graduated, 15 students received master degree and 10 students received PhD degree.

New study programs, accredited by the end of 2014, started in 2015/2016. The study program "Astronomy and astrophysics" consists of 2 modules (Astrophysics, Astroinformatics) at undergraduate and Master levels. At PhD level there is only one module "Astronomy and astrophysics" with more than 30 elective courses. Within the study program "Mathematics" there is a module "Astronomy" at undergraduate level, and module "Astronomy and Mechanics" at Master level.

In 2017 the Department of Astronomy is included in the University Heritage of Serbia (Kovačević, 2017).

The students had summer practice - training in observations and data reduction at the Ondřejov Observatory in 2014 (2 students from Belgrade and 1 student from Novi Sad), in 2015 (5 students from Belgrade and 1 student from Novi Sad), whereas in summer 2017 only one student from Belgrade worked under the supervision of Czech colleague prof. Michaela Kraus (Marčeta, 2017).

Three summer practices lasting 3 days have been organized at the Astronomical Station Vidojevica (ASV): in May 2015 (14 students), in April 2016 (10) and in June 2017 (8). Twenty three students from Belgrade and nine students from Novi Sad in total participated in these three practices at ASV (Ilić, 2017). The students practices at ASV were organized by prof. Dragana Ilić (Department of Astronomy, Belgrade) and prof. Tijana Prodanović (Department of Physics, Novi Sad).

The Astronomy Students Workshops (ASWs), organized since 2007 by the Department of Astronomy in Belgrade and the Department of Physics in Novi Sad are growing in popularity among students. The ASWs give the students of undergraduate, master and PhD studies an opportunity to present their work (seminars, master/PhD thesis research, and summer practices). The 8th ASW was held in April 2015 at the Department of Physics in Novi Sad (38 students), the 9th ASW in April 2016 at the Society "Milutin Milanković" in Belgrade (35 students) and the 10th ASW in November 2017 in Novi Sad with 36 students (Ilić, 2017; Petrović, 2017).

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), "Tor Vergata" Rome, Padova, Göttingen and Belgrade (see website www.astromundus.eu). The University of Belgrade (Faculty of Mathematics) offers the 3rd and 4th semester of the Master program. Since 2011/2012 thirty five students enrolled a semester at the Faculty of Mathematics, 5 students defended the Master thesis in Belgrade (3 in 2011/2012, 1 in 2015/2016 and 1 in 2016/2017), 11 master theses were co-mentored by UB out of which 3 got the award for the best master thesis in generation. In 2014 AstroMundus was included in EMJMD catalogue as one of the best programs, getting the possibility to apply for additional three academic years (until 2018/2019). In the new cycle, five more associate partners are included in the project: Max-Planck Institute for solar system research, National Institute for Astrophysics - Astronomical Observatories of Rome and Padova, Astronomical Observatory Belgrade and Gran Sasso Science Institute. In June 2017 AstroMundus was announced as one of the most successful programs by the group of experts from Directorate-General for Education, Youth, Sport and Culture of the European Commission (Ilić, 2017).

The Department of Astronomy continued to organize regular seminars on different topics in astronomy on every second Tuesday throughout the academic year, so that 40 seminars have been held in this triennial period. Sixteen seminars were also held

at the Astronomical Observatory in Belgrade.

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), and as an optional course "Selected topics in astronomy" (4th year) for all modules of the study program "Mathematics". Until 2015/2016 two optional courses "Stellar astronomy" and "Ephemeris astronomy" were offered to the students (1st/2nd year) of the study program "Informatics". Since 2015/2016 two optional courses "Fundamentals of Astronomy" and "Fundamentals of Mechanics" have been offered to the 2nd year students of Informatics.

Lectures in optional courses "Introduction to Theoretical Mechanics" (for the 4th year students of mathematics) and "Continuum Mechanics" (for the master students of theoretical mathematics and astronomy) are given by professors of the Department of Astronomy. The first master thesis in Mechanics was defended at the Department of Astronomy in September 2017. This thesis was selected among the five best theses at the contest of students works organized by Mathematical Institute of Serbian Academy of Sciences (Kovačević, 2017).

At the Faculty of Physics astronomy is taught as part of the curriculum with a compulsory one-semester course Fundamentals of astrophysics at the 1st year of master studies for physics teachers division, and an optional one-semester course under the same name for the students of the 1st year of B (theoretical) division and for the students of the 2nd or 3rd year of A (general) division. In three school years, from 2014/2015 to 2016/2017, on average 35 students per year took this course. Since 2015 (new accreditation) Fundamentals of astrophysics is a compulsory one-semester course for the students of the 4th year of A (General Physics) division. Additionally, a course "Fundamentals of astronomy" is introduced as a one-semester optional course at the master studies for A division.

At the Faculty of Civil Engineering, a compulsory course "Geodetic astronomy" (4th year) is taught to the students of geodesy. At the Faculty of Geography, basic astronomical topics are taught within the first-year course "Mathematical Geography" for the students of General division and Geography teachers division (Tadić, 2017).

Two new university textbooks: "Astrobiology" by Anđjelka Kovačević and "Active galactic nuclei" by Luka Č. Popović and Dragana Ilić are published by the Faculty of Mathematics in 2016 and 2017, respectively.

New accreditation at the Department of Physics of the Faculty of Natural Sciences (FNS) at **the University of Novi Sad** is in progress. According to new programs, which are expected to start in 2018/2019, eleven optional courses in astronomy and astrophysics will be offered at the undergraduate studies in Physics (there will be no more a division physicist-astronomer-astrophysicist at undergraduate studies), whereas the master studies in astrophysics will have focus on high energy astrophysics. In the past three years 27 students enrolled astronomy undergraduate studies and 5 students enrolled master studies at the Faculty of Natural Sciences in Novi Sad. Five students graduated and no students received the Master degree (Prodanović 2017).

In 2016 the FNS obtained COST project "Chemical Elements as Tracers of the Evolution of the Cosmos" (prof. Tijana Prodanović is a project manager), as well as a bilateral cooperation with Slovenia (2016-2017). In 2017 the FNS signed the cooperation agreement with ICRANET (International Center for Relativistic Astrophysics

Network) with the aim of networking, linking, common databases, cooperation in research, study exchanges, organization of joint events and cooperation on doctoral studies.

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, 2017).

At the Institute of Physics of the Faculty of Natural Sciences of **the University of Kragujevac** there is a one-semester (2+2) optional course, "Astrophysics and Astronomy", for the 5th-year (master) students of all three modules of Physics (Simić, 2017). Almost all the students choose this course.

New accreditation is in progress. The course "Astrophysics and Astronomy" is expected to be a compulsory course for the module A1.

New university textbook "Fundamentals of Astronomy and Astrophysics for the students of Physics (Part I)" by Luka Č. Popović and Saša Simić is published by the Faculty of Natural Sciences of the University of Kragujevac in 2017.

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. Two hours per week have been added for tutorials. Two optional courses "Fundamentals of planetology" and "Stars and stellar systems" are introduced at Master level. The course "Fundamentals of Astrophysics" 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, 2017).

At the Department of Biology, an optional course "Fundamentals of astrophysics with astrobiology" is taught at the third study year. At the Department of Geography, an elective course "Astronomy" is offered to the first-year master students. About 50-70 students attend the astronomical courses at the University of Niš. At the Department of Geography, a course "Mathematical geography" (2+2) includes some basic astronomical topics (Tadić, 2017).

The Department of Physics possesses five amateur telescopes (Mead LX 200, Sky-watcher 120 X 1000, Lunt telescope LS60T, Vixen refractor and school Russian spy-glass). Apart from a dome that is installed on the roof of the Faculty, the Department of Physics now has a new Laboratory for astrophysics, astrobiology and astronomy located in the attic of the Faculty. It is used for seminars and lectures. Moreover, it is connected to the observatory, so that it can be used for the telescope control. There is a permanent photo exhibition (about 30 astrophotographs) by Miodrag Sekulić (Gajić, 2017).

At **the University of Priština in Kosovska Mitrovica** a one-semester 2-hour per week compulsory 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, 2017).

3. 1. RESEARCH IN ASTRONOMY

The big news for astronomy research and education in Serbia is the mounting of new 1,4 m telescope "Milanković" on the mountain Vidojevica in June 2016.

4. PUBLIC OUTREACH

Public astronomy education in Serbia was realized mainly through the lectures held in: Kolarac, Belgrade Youth Center, Students Cultural Center, Serbian Academy of Sciences and Arts, in two Planetaria (Belgrade and Novi Sad) and in public observatories, through special events (Festival of Science, Night of Researchers, Night of Museums, Book Fair, etc.) and various activities of 24 amateur astronomical societies.

The AS "Eureka" from Kruševac (active since 2010) was registered in 2016. New astronomical society "Vlašići" for archeoastronomical and etnoastronomical research was founded in 2014 in Belgrade.

Apart from its usual activities: Astronomy courses for beginners, Belgrade astronomical weekends, Summer Schools of Astronomy (in August) and Special topical meetings "Summer Astronomical Meetings" (the 18th on Small Solar System Bodies held in 2015, and the 19th on Serbian Astronomical Cultural Heritage, held in 2017), the AS "Rudjer Bošković" (Belgrade) organized the 1st Belgrade Summer School of Astronomy in August 2017 (Simonović, 2017).

In the past three years the Astronomical Society "Rudjer Bosković" and the Society of Astronomers of Serbia used the mobile planetarium as a tool for astronomy communication. Also, lectures were held in many primary schools all over Serbia. The societies had cooperation with Serbian scientific television, Center for the promotion of science, Mensa, Serbia, etc. (Aleksić, 2017).

Regular lectures on Thursdays have been held by ADNOS in Planetarium within Petrovaradin fortress. Since 2016 Stargate stage has been organized by ADNOS during EXIT. Twenty two lectures were given during the "Novi Sad School of Astronomy" to about 30 participants. In 2017 ADNOS organized the Festival of Night Sky with the Academy of Art of Novi Sad. Since December 2015 ADNOS has made and used digital planetarium under the dome of Planetarium. ADNOS became a part of the focus group for the future of Petrovaradin fortress (Prodanović, 2017).

Astronomical Meetings of Vršac (AMV) have been organized 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). "Eureka" from Kruševac organized Eureka Days and Eureka Picnic. There are several examples of an intensive collaboration among the amateur astronomical societies in Serbia - astronomical camps Letenka, Sivčina, Golija and Jastrebac. The international astronomical camp "Letenka" is one of the biggest camps for the popularization of astronomy in Europe. About 200 people (mostly secondary school and university students) take part in "Letenka", which takes place every year in July on the mountain of Fruška gora.

More details on the activities of the amateur astronomical societies in Serbia can be found on their web sites given in Table 1 of the paper by Atanacković (2017), in the paper by Zorkić (2017), as well as on the Astronomical Magazine (AM) web site. Their usual activities and equipment are described in detail in the paper by Atanacković (2012).

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

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