

TEACHING OF ASTROINFORMATICS AT THE UNIVERSITY OF BELGRADE

NADEŽDA PEJOVIĆ

Faculty of Mathematics, University of Belgrade

E-mail: nada@matf.bg.ac.rs

Abstract. The aim of this paper is to present the studies of astroinformatics at the Faculty of Mathematics of the Belgrade University. The studies of astroinformatics were started in 2009 and they are organized according to the Bologna declaration.

1. INTRODUCTION

The Bologna Declaration is the main document which has conditioned the education reorganization throughout Europe. This declaration was signed in 1999 by the education Ministers of the EU member-countries. Till the present moment this document has been signed by a majority of countries including ours as well. The Bologna process is aimed at the formation of a unique European system of university teaching and scientific research till 2010. In this way one tends to form a more efficient system of advanced education in Europe which is in accordance with the world knowledge market.

From the school year 2006/07 at the Faculty of Mathematics the teaching in mathematics, informatics and astronomy has been reformed in accordance with the Bologna process. According to the Law of the Republic of Serbia concerning the post-secondary school education, which follows the Bologna Declaration, there are three levels of university education:

Basic academic studies lasting 3 or 4 years. The condition to finish them is to collect 180 or 240 EPTS points. In this way a student acquires the bachelor degree and they may continue toward the master studies.

Diploma academic studies lasting 5 years and to finish them one needs 300 EPTS points. A student after finishing the basic studies may, possibly having also a working position, continue during one or two years in order to gather additional 60 or 120 EPTS points (up to 300), through which one acquires the master diploma.

PhD academic studies last 3 years and to finish them one needs 180 EPTS points, provided that the diploma master studies have already been finished. By finishing these studies and passing the PhD examination one acquires the PhD degree..

EPTS (European Point-Transfer System) is a unique system of evaluating a student's effort in knowledge acquiring for each subject included in a curriculum. The number of points per subject is different. It is not directly dependent of the number of lessons (lectures and exercises), but it also involves the estimate of the total time which a student needs to master the subject. The points are not marks. Every student gets an equal number of points for the same subject, independently of the mark obtained at the examination. The points are assigned only after successful examination.

At the Faculty of Mathematics the Basic Academic Studies of mathematics and astronomy last 4 years (240 EPTS), i. e. 3 years in the case of informatics (180 EPTS). After finishing the Basic Academic Studies a student becomes: mathematician, informatician or astronomer. The novelty is that after finishing the studies in addition to the certificate a student also gets an official document named Supplement to Certificate. This document contains a number of details: curriculum, list of subjects, number of EPTS points for each subject, subject contents, as well as the mark obtained at the exam. The Certificate and Supplement are delivered in both Serbian and English and they are in accordance with the documents of European universities.

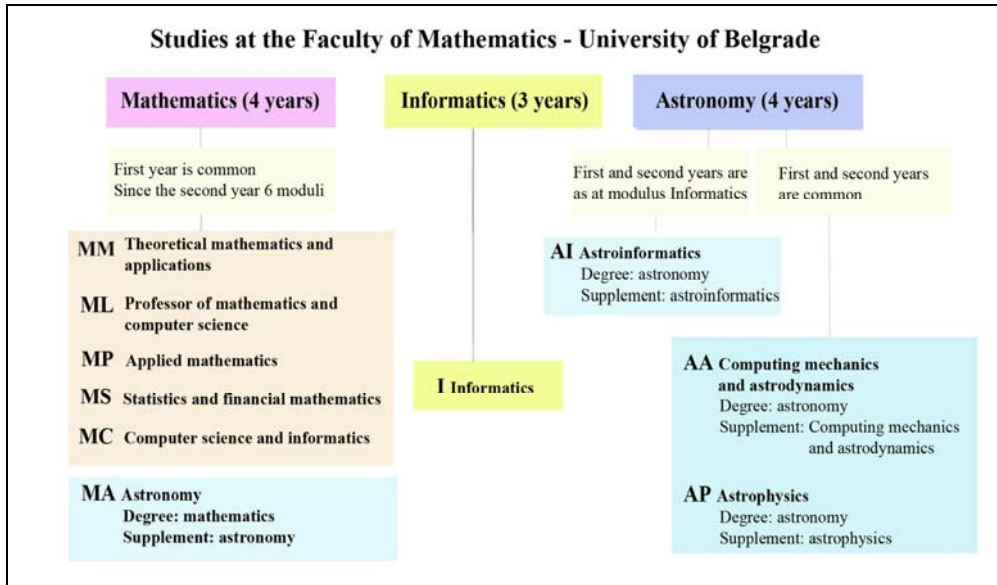
In the year 2009 the Faculty of Mathematics finished its accreditation for three directions of studies (mathematics, informatics and astronomy) which are subject to a further ramification of several moduli. The studies following new curricula also started in the autumn of 2009. The basic academic studies in mathematics after the first year have six moduli, in astronomy three moduli (two at the beginning and one after the second year), whereas in informatics there is only one modulus. The Certificate will contain the name, mathematician, informatician or astronomer, whereas the Supplement will give a detailed modulus description.

More detailed information concerning the studies within the directions of mathematics and informatics and the corresponding moduli can be found on the Internet Site of the Faculty of Mathematics. Here more detailed information will be given for the direction of astronomy only.

2. ASTRONOMY

From the scheme bellow one can see that astronomy is studied in the framework of four moduli. One of them belongs to direction of mathematics, the other three to direction of astronomy:

1. **MA** - direction **Mathematics** – modulus **Astronomy**
2. **AP** - modulus **Astrophysics**
3. **AA** - modulus **Computer Mechanics and Astro dynamics**
4. **AI** – modulus **Astroinformatics**



3. MODULI WITH TRADITION

Modulus MA – Astronomy has been present at the Faculty of Mathematics for decades. It is studied in the framework of the Direction of Mathematics and after the first year a student has the option of choosing the modulus of astronomy. According to the earlier curriculum a student after finishing the studies became a mathematician-astronomer; according to the new one in the Certificate it will be written mathematician and in the Supplement astronomy. As in the case of the earlier curriculum, students taking degree in the framework of this modulus may teach mathematics, informatics and astronomy in primary and secondary schools. This modulus offers the possibility of learning high-class mathematics which has many applications in astronomy. Only with such a high knowledge level in mathematics any person taking degree, in addition to the study of classical problems of astronomy, can be active in the field of the advanced research like studying cosmological models.

Modulus AP - Astrophysics has been also present at the Faculty of Mathematics for decades. According to the earlier curriculum a student after finishing the studies became an astrophysicist; according to the new one in the Certificate it will be written astronomer and in the Supplement astrophysics. Students studying in the framework of this modulus can learn high-class astronomy and physics so that with great success they can later study complex astrophysical processes on distant and not well-known celestial bodies and systems, such as stars, star clusters, nebulae, galaxies, active galaxies, black holes, quasars and blazars. The data about these distant worlds are collected at all wavelengths of the electromagnetic spectrum, from gamma to radio ones. After taking the degree astrophysicists will have the opportunity to get positions in addition to those concerning the astrophysical research, also as physicists at scientific institutes, universities and schools (primary or secondary).

4. NEW MODULI

Modulus AA – Computer Mechanics and Astrodynamics contains computer science dominant in the third and fourth years of studying. To this modulus and to that of Astrophysics the first two years are in common (see the scheme). After two years students have two options: towards physics by choosing the Astrophysics modulus or towards computer science by choosing the modulus of Computer Mechanics and Astrodynamics. Taking degree in Computer Mechanics and Astrodynamics students will get a certificate with name astronomer, whereas the Appendix will contain Computer Mechanics and Astrodynamics followed with the list of all subjects covering computer science, mechanics and astronomy. The contents of subjects from computer science will show what kind of new information technologies are mastered by students; they are applicable not only in astronomy and mechanics, but in economy, financial institutions and software houses, as well.

Modulus AI – Astroinformatics has two years in common with the direction of informatics. As the studies of informatics last 3 years, and those of astronomy 4 years, it follows that by taking degree at the four-year modulus of astroinformatics one also finishes the complete triennial studies of informatics. In the Certificate it will be written astronomer, in the Supplement astroinformatics. Similarly to the case of the preceding modulus, students will be able to apply the knowledge of informatics and information technologies, necessary in the space research, also in other situations with all rights as any student taking degree in Informatics.

5. PROGRAM OF STUDIES OF ASTROINFORMATICS

Among the products of our time is the informatic revolution. The data transfer becomes more and more. In this new world the role of computer science and informatics has grown enormously. There is practically no activity field deprived

of applying computer science and informatics. On the other hand, in the world enormous means are invested into astronomy and space research. For instance, at the moment a few observatories orbit the Earth, such as the Hubble Space Telescope and Chandra, sending continually the data of high importance to the space research. In addition to them there are many cosmic vehicles sent to the most remote parts of the Solar System, then many artificial Earth satellites, as well as a large number of telescopes situated at observatories throughout the surface of the Earth. An enormous body of data about our cosmic neighbours, the Moon, the Sun, the planets, their satellites, asteroids, comets, meteors, trans-neptunian objects in the Kuiper belt, small icy bodies of the Oort cloud, but also about distant worlds, like stars, extrasolar planets, star clusters, nebulae, galaxies, black holes and quasars, are continually collected. The majority of instruments are computerized and the observations are automatic. Without mathematics, computer science and informatics any use of these world databases and data treatment is unthinkable. Astronomers after finishing these new directions can successfully apply their acquired knowledge of mathematics except in astronomy, also in all other activities where programmers and informaticians find their job. It should be mentioned that on lists of unemployed persons there are neither programmers nor informaticians.

Now we shall present in more details the program and the content of the subjects that are taught at the modulus astrophysics. First, we note that the interest of students in studying astronomy considerably raised since the modulus of astrophysics was introduced. For example, the number of the enrolled students in astronomy doubled in 2010 in respect to the previous school year. Most of them are in fact the students of astrophysics.

The courses at the modulus of astrophysics are divided into three almost equal in size groups: astronomy, computer science and mathematics. Mathematics and informatics are mostly taught in the first two years of studies. In the third year of studies, the number of courses in astronomy and informatics is same. In the fourth year of studies, students are specialized in astronomy. All main branches of mathematics are taught through the specialized courses such as discrete structures (mathematical logic and combinatorics), mathematical analysis (calculus), algebra, geometry, computational mathematics and probability and statistics. Courses in informatics are the modern subjects in computer science and they cover algorithms, data bases, programming languages and Internet oriented courses. Finally, courses in astronomy are the standard basic courses in astronomy and they give the sufficient knowledge to the student to continue further specialization in astronomy and graduate studies. There are several courses in astronomy with heavily use of computers. Such a course is for example *Processing of astronomical observations*. Every student who graduated astrophysics also has the diploma of informatics (the modulus **I**, *Informatics*) and in fact he can further specialize in three professions: astronomy, programming and teaching astronomy

and astrophysics in the elementary and secondary schools. Even if the studies of astrophysics just started (in 2009), our experience with students and teaching of astrophysics is fine.

6. CONCLUSION

Anyone fond of astronomy can study it together with mathematics, physics, computer science or informatics by choosing one of the moduli named Astronomy, Astrophysics, Computer Mechanics and Astrodynamics or Astrophysics.

A Certificate of the Faculty of Mathematics in Belgrade has been recognised abroad. Persons having it, in addition to positions in primary or secondary schools, universities and scientific institutes, can find positions within a wide range of various activities including financial institutions, economy, software houses. The internet site of the Faculty of Mathematics offers the possibility of more detailed informing not only concerning undergraduate studies, but the diploma and PhD ones as well, for the case of mathematics, informatics and astronomy.

The curricula with subject names and contents for each subject for all three directions of the Basic Academic Studies at the Faculty of Mathematics can be found at <http://www.matf.bg.ac.rs>.

The list of courses in Astrophysics

First year – first semester				First year – second semester			
	Course	classes	EPTS		Course	classes	EPTS
1	Programming 1	3+3+0	8	1	Programming 2	3+3+0	8
2	Introduction to the organization of computers	3+2+0	6	2	Introduction to the architecture of computers	3+2+0	6
3	Discrete structures 1	3+2+0	6	3	Discrete structures 2	3+2+0	6
4	Linear algebra	3+2+0	6	4	Analysis 1	3+2+0	6
5	General astronomy A	2+2+1	5	5	General astronomy B	2+2+1	5

TEACHING OF ASTROINFORMATICS AT THE UNIVERSITY OF BELGRADE

Second year – first semester				Second year – second semester			
	Course	classes	EPTS		Course	classes	EPTS
1	Algorithms and data structures	3+3+0	7	1	Analysis and construction of algorithms	3+3+0	6
2	Architecture and operating systems	3+2+0	7	2	Introduction WEB and Internet technologies	3+2+0	6
3	Geometry	3+2+0	6	3	Object oriented programming	3+2+0	6
4	Analysis 2	3+2+0	6	4	Analysis 3	3+2+0	6
5	General astrophysics A	2+2+1	6	5	Algebra	2+2+1	6

Third year – first semester				Third year – second semester			
	Course	classes	EPTS		Course	classes	EPTS
1	Relational data bases	3+3+0	8	1	Artificial intelligence	3+3+0	8
2	Compiling of programming languages	3+2+0	6	2	Celestial mechanics	3+2+0	6
3	Positional astronomy A	3+2+0	6	3	Practical astronomy A	3+2+0	6
4	Processing of astronomical observations A	3+2+0	6	4	Introduction to numerical mathematics	3+2+0	6
5	Probability and statistics	2+2+1	5	5	Selected topics	2+2+1	5

Fourth year – first semester				Fourth year – second semester			
	Course	classes	EPTS		Course	classes	EPTS
1	Selected topics	3+3+0	23	1	Operating systems	3+3+0	6
2	Selected topics	2+2+0	4	2	Theoretical astronomy A	3+2+0	5
				3	Selected topics	3+2+0	5
				4	Selected topics	3+2+0	5
				5	Selected topics	2+2+1	5

Further details on the courses (the content, professors, etc) and selected topics (special courses) can be seen at the address <http://www.matf.bg.ac.rs>.

Note: 2+2+1 in the column **classes** in the table means that there is one lecture lasting two hours (2 X 45 minutes), one exercise lecture (oriented to problem solving) lasting three hours and one hour of practice (usually devoted to the student seminar works).