

# Graduate programme in astrophysics in Split

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**Abstract.** Beginning in the autumn of 2008, the first generation of astronomy master's students will start a two-year course in Astrophysics offered by the Physics Department of the University of Split, Croatia (<http://fizika.pmfst.hr/astro/english/index.html>). This unique master's course in south-eastern Europe, following the Bologna convention and given by astronomers from international institutions, offers a series of comprehensive lectures designed to greatly enhance students' knowledge and skills in astrophysics, and prepare them for a scientific career. An equally important aim of the course is to recognize the areas in which astronomy and astrophysics can serve as a national asset and to use them to prepare young people for real life challenges, enabling graduates to enter the modern society as a skilled and attractive work-force. In this contribution, I present an example of a successful organization of international astrophysics studies in a developing country, which aims to become a leading graduate programme in astrophysics in the broader region. I will focus on the benefits of the project showing why and in what way astronomy can be interesting for third world countries, what are the benefits for the individual students, nation and region, but also research, science and the astronomical community in general.

**Keywords.** Education in astronomy, astronomy in Croatia, sociology of astronomy

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## 1. Introduction

The knowledge-based economy is founded on discoveries and innovations. The power of a nation is measured by its ability to stimulate discoveries and capacity to innovate. A nation cannot achieve this without increasing its educational levels and intellectual competencies. Moreover, for a small nation, building knowledge-based society is more than an economic necessity – it is also a strategy for preserving its culture and identity.

Astronomy, as a scientific discipline, is a valuable incubator of new ideas, discoveries and enterprises, driven by the synergy of sophisticated technologies, different natural sciences and the wish to understand our Universe. Astronomy has also a unique public appeal, which enables it to inspire young generations and stimulate their curiosity, creativity and appreciation for science.

In developing countries, astronomy is, however, often perceived as an abstract and expensive science, without visible end-products through which it is possible to quantitatively 'weigh' its usefulness. Even in developed countries, in the times of economic uncertainty, astronomy falls into the group of fundamental sciences which are the first to lose governmental monetary support. It is the duty of professional astronomers to oppose this opinion, and to demonstrate the benefits related to astronomy as a science and, especially, as an educational option for bright young people of all ages and school levels.

The Astrophysics Initiative in Dalmatia (ApID) is an attempt to do this and promote the growth and development of astrophysics in Dalmatia, a southern region of Croatia. ApID is a collaboration of projects, institutions, and individuals, from professional scientists to amateur astronomers, sharing the common interest in astronomy and

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astrophysics. The strategy of ApID is to ensure its sustainability through a carefully designed combination of educational, research, and outreach programmes. The operational performance and strength of ApID are enhanced by the synergy of a public university (the University of Split) and a non-profit non-governmental organization (the Society znanost.org). The backbone of ApID is the Graduate Programme in Astrophysics at the Department of Physics at the University of Split (GPAS), Croatia, which is the main topic of this contribution to the Special Session 5. The main objectives of GPAS can be summarized as follows:

- to provide the graduates with know-how to continue in diverse career paths as well as to make them attractive targets for a range of employers in different branches of business, government and finances;
- to attract young people for careers in science and technology;
- to establish connections with other disciplines present at the University of Split, other Universities in Croatia and abroad in order to actively promote interdisciplinary sciences;
- to promote top level research in astronomy in Croatia, and
- to enhance the quality of existing graduate level education in the region and set an example to other educational institutions in south-eastern Europe.

Here, I outline the graduate programme focusing on aspects which differ from existing and more classical courses (Section 2). This is followed by a discussion about the benefits that such a study can bring to the students, to the region, but also to us, the astronomical community (Section 3). Finally, I conclude with highlights of the GPAS (Section 4).

## 2. Study astrophysics in Split

GPAS is supported by the Department of Physics of the University of Split, which is a part of the Faculty of Natural Sciences, Mathematics and Kinesiology. Recently, following the Bologna process (standardization of higher education in Europe), the Department of Physics restructured its courses now offering three-year undergraduate and two-year MSc (master's degree) graduate study programmes. The MSc in Astrophysics will be given in English, enabling students from other countries to follow the courses in Split, thereby increasing their mobility and exchange of experiences.

**Students.** The MSc programme in Astrophysics is open to Croatian and international students, who completed their undergraduates studies (BSc) in physics or related subject. In the modern world, it is necessary to actively work on attracting bright students. Clearly, the best undergraduate students should be encouraged to apply to the programme. Possible candidates, however, could be identified and attracted to astronomy at even younger age, among the gifted high-school or even elementary schools pupils. This means that a part in the organization of the graduate studies also includes an active outreach through which GPAS will be present in the media and news, will actively participate in the organization of local and regional scientific events for young people, and will promote the popularization of science to the general public.

**Lecturers.** Currently, there are no professional astronomers at the Department of Physics in Split. The expanding department will in the following years offer positions for astronomers, but the bulk of the astronomy specific teaching at GPAS will be given by visiting lecturers. Some of these lecturers are Croatian astronomers working abroad, while others are foreign scientists. The rest of the courses (non-astronomy related, but necessary for a completion of the master degree in Astrophysics) will be given by local physics faculty. The vising lecturers will not need to spend a whole semester in Split, but rather a few weeks necessary for completing their course.

**Courses and Timetable.** The courses are divided between required and elective courses. The aim is to give a thorough astrophysical background, which is supplemented with optional courses in general physics, computer science and humanities (history, philosophy, etc). Since large section of courses will be given by visiting lecturers, the whole educational programme is organized in blocks. One block, lasting between 2 to 4 weeks, contains the lectures as well as the exam. The emphasis of the studies on the research is evident in the fact that in all semesters students will be required to participate in scientific projects. Moreover, the last semester is completely devoted to a research project which will become the master thesis. The aim of these projects is to encourage students to tackle complex programmes and learn methods of the scientific research. The most important aspect, however, is to enable students to work in an international environment at astrophysical centres of excellence. They will have to work on projects offered by the lecturers, visiting their institutions abroad and producing publishable scientific results.

**The first light.** The new graduate programme will commence during the fall of 2008 when the first group of Croatian students following the Bologna process will finish their BSc.

### 3. Benefits of the graduate programme

The position of astronomy in early societies was very much different than it is today. First astronomical exploits were very practical, from the determination of the seasons necessary for the agriculture, which fed the stratified human societies, to predictions of terrifying eclipses and explanation of the heavens. Astronomy was a very practical and necessary system of theoretical knowledge, with deep cultural and social consequences. Last few hundred years, however, saw a reverse of the medal. Astronomy, supported by physical laws of nature, was turning towards theoretical knowledge of Universe, its structure and properties, loosing its practicality and usefulness for everyday aspects of human lives. On the other hand, younger sciences like physics, chemistry, biology and their various mixtures (medicine, engineering . . .), with their technical applications, started changing the human society as well as its influence on the Earth. Astronomy did little in this 'progress'†, becoming more and more academic and idealistic pursuit of the nature of the Universe. Today, it is often considered a fundamental science, remote and useless for 'real' life, perhaps an exercise for the mind, interesting in terms of secular human culture; an entertainment, although rather expensive, for the general public.

Astronomy in the modern world, however, is much more than that. It still makes humanistic, educational and technical contributions to our society. Rather than going through a list of recent contributions from astronomical research, I will focus on a more specific aspect of benefits that a study of astronomy can offer to the students and to the region hosting an astronomical institution.

#### 3.1. *Benefits for the students*

It is self-evident that training in science opens doors to a scientific career. It is, however, often not clear to the general public that the same training can be very attractive to industry and different businesses as potential employers of skilled people. An objective

† One should, however, remember the crucial role of astronomy in navigation and, hence, in the great geographical discoveries and world trade until the recent advent of satellite navigation. The importance of astronomy for economy of the sea-faring nations is evident also in the support astronomical research was getting from the governments: both Paris and Greenwich Observatories were opened in 17<sup>th</sup> century with purpose to perfect the art of navigation, increase the maritime power of the nations and, in general, make the seafaring safer.

of GPAS is to produce world-class graduates with the necessary skills to become local and global leaders and entrepreneurs.

Industry and finances are generally not concerned about the specialization of an academic course. They are more interested in broader skills obtained by students, which can be transferred to the work place. A master's course in astronomy is actually well suited in this respect. The interdisciplinary nature of astronomy provides a full framework for illustrating to the students the unity of natural phenomena and the evolution of scientific paradigms that explain them. On a more pedagogical level within higher education, teaching astronomy to master students prepares them for a broad range of scientific disciplines ranging from purely academic, such as astrophysics, to widely applicable tasks of engineering and computer science. GPAS aims to leave a number of transferable skills to its graduates:

- mathematical, computing and modelling skills with scientific literacy
- tackling complex problems and handling incomplete and large data sets
- cooperating in international teams and projects
- preparing and executing projects (often on tight deadlines)
- presenting an account of work to colleagues and to broader audiences

It is important to stress that the above mentioned skills provide a solid base not only for a career in science, but also in different branches of business. It is the synergy of different sciences used in astronomical research that offers a broad spectrum of transferable skills and know-how for diverse career paths.

### 3.2. *Benefits for the region*

The region concerned in this section is primarily Dalmatia with its capital Split. On a slightly higher level it, of course, concerns Croatia as the country where the master study is organized. It is, however, easy to generalize towards a larger region of South-East Europe, but certain aspects of the graduate programme apply to the whole Europe, both to its political and geographical entities.

Modern economy of a nation depends on its ability to compete technologically with other nations. This ability directly translates in the number of technically trained people that are able to use existing technologies and develop new ones for international markets. In addition to that, the quality of environment depends on developing safe, clean industries and sources of energy. This, also, can be accomplished only by imaginative and highly trained scientists and engineers. However, even governments of developed countries recognize the steadily decreasing number of students interested in pursuing technical careers as a major concern for the future development of their nations. To overcome this downward trend it will be necessary to support those activities that stimulate young people toward scientific thinking and the development of mathematical and technical skills. The subject of astronomy is inherently interesting to young people, thereby keeping them interested in science, whilst they learn fundamentals of mathematics, statistics, physics, chemistry, etc. GPAS follows the trends of physics departments in developed countries which started offering astronomy options in their curriculum, resulting in an increased interest in bachelor and master degree programmes in astronomy. GPAS aims to provide a highly educated and scientifically literate work force required by their home country for its future development.

A big problem facing developing countries is the *brain-drain*, the exodus of highly educated individuals who go to wealthy nations capable of offering well payed or other specific jobs (such as research positions in astronomy). Croatia and the region of Split suffer from this effect as well. A graduate course in astronomy, however, can be used to reverse the *brain drain* into *brain gain* by attracting astronomy professionals (either

Croatian or foreign) to take posts in Split and promoting a modern programme which offers transferable skills to its students preparing them for different career paths.

GPAS should also be interesting to the relevant bodies in the European Union, since it is fully compatible with the European standards for high education (Bologna process), emphasizes the mobility of students between the countries, especially the neighbouring countries of Croatia, and its existence will enhance the quality of existing graduate level education in the region, as well as set an example to other educational institutions in south-eastern Europe.

### 3.3. *Benefits for astronomy*

As a final remark in this section, it does not hurt to stress that with a new graduate programme in astronomy the whole astronomical community also gains. An obvious benefits are the job openings and a popularization and spread of astronomy to the general public (who is paying for most of the astronomical research). Possibly the most interesting gain is opening of a new channel for introduction of young bright people into the world of top level astronomical research. The graduate programme in Split supports this aspect by linking professional scientists and students. This is achieved by bringing astronomers (lectures, see Section 2), who work at international institutes and are involved in different international projects, to Split to give lectures and offer master projects to the students. On the other hand, they will meet capable students with different backgrounds and eager to do astronomical research but coming from Croatia and neighbouring countries which do not have developed astronomical infrastructure nor are members of major international projects or organizations. To our knowledge, the astrophysics graduate course in Split is the first programme of this scale offering the link between astronomically developed western and underdeveloped south-eastern Europe.

## 4. Conclusions

Astronomy is a lively natural science that can offer a broad range of products to the general community: from 'pretty' pictures to an understanding of the structure of the Universe, from technological advancements to educational programmes. Many of these are applicable and useful for developing countries. In this work I focussed on the tertiary education, on the organization of a graduate course in astrophysics and on the benefits it offers to the students and the host country. Here I summarize the main points. The aims of GPAS are:

- to recognize the areas in which astronomy and astrophysics can serve as a national asset and to use them to prepare young people for real life challenges;
- to attract young people for careers in science and technology;
- to set the example of excellence to be followed by other existing higher education programmes in the region and demonstrating to the public that investing in science is the right thing to do;
- to bring the top science and technology research to Croatia, enhance the transfer of technology to Croatia through international collaborations and joint projects with international centres of excellence, and help disseminate the skills and knowledge necessary for the establishment of similar world-class centres of excellence in the region; and
- to actively participates in the process of brain-gain by attracting Croatian science diaspora and foreign scientists to actively participate in the Croatian education system through the transfer of their skills and knowledge to Croatia.

The astrophysics graduate course is fully compatible with the European educational standards, and its international orientation (curriculum, language and lecturers) and

research excellence will serve as a bridge between the existing and future EU states, empowering Croatia as a future EU member.

### **Acknowledgements**

I would like to thank Dejan Vinković, for useful discussions and careful reading of the manuscript.

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