Organizations, People and Strategies in Astronomy 2 (OPSA 2), 175-194
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ASTRONOMY IN POLAND

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Abstract. A historical outline of the development of Polish astronomy shows its strong dependence on national history. The present state and main activities of Polish astronomical institutes and organizations are described in the context of the general management and funding of science in the country.

1. Historical Introduction

The beginnings of astronomy in Poland were closely related to the creation of its first university. The last King from the Piast dynasty, Kazimierz Wielki (Casimir the Great, 1310-1370), founded in 1364 in Kraków (Cracow) the so-called *Studium Generale* consisting of three departments: liberal arts, medicine and law. After the King's death in 1370, and in view of the total lack of interest in science by his successor, Louis d'Anjou (1326-1386), the Cracow Academy did not develop any further for the next several decades.

The situation improved with the election to the Polish throne of Jadwiga d'Anjou (1373-1399), the 11y old daughter of King Louis. She was crowned in 1384 (as a King and not a Queen, to emphasize her position as a monarch and not a mere crown consort). Two years later, she married the Great Duke of Lithuania, known after he was baptized as Władysław Jagiełło (∼1351-1434), the founder of the Polish-Lithuanian Jagiellonian dynasty. Both Jadwiga, renowned for her excellent education and broad cultural interest, and her husband did a lot to restore the academic activity in Cracow. The solid financial foundation of the Academy was created by Jadwiga's generous bequest of her personal jewelry. Although this philan-

thropic gesture was not the main reason, Jadwiga after a somewhat lengthy process was canonized in 1997 for her charity works.

Following the good example of the Kings, a wealthy Cracow citizen, Jan Stobner, founded in 1406 a chair of astronomy as a part of the department of liberal arts. Professors of astronomy at that time were teaching geometry, arithmetic, principles of music, and the Ptolemaic theory of planetary movements. The practical part of astronomy dealt with calendar keeping and reduction of astronomical ephemerides to the local meridian. Although astrology was closely related to astronomy, a separate chair of astrology was established in Cracow Academy almost half a century later, in 1459.

The first Cracow astronomer who influenced markedly the state of astronomical research in Poland was Wojciech Brudzewski (1446-1495), from $\sim$1487 a professor at the Academy. His main works were the *Tabulae Resolutae* – Alphonsian Tables of planetary ephemerides reduced to Cracow and *Commentum planetarium in theoricas Georgii Purbachii*, containing many critical remarks on the consistency and reality of the Ptolemaic system, however without any doubts about the truth of the geocentric system itself. Most probably Copernicus attended his lectures when studying the liberal arts at the Cracow Academy in 1491-1496.

The importance of Mikołaj Kopernik (Nicolaus Copernicus, 1473-1543) work in the creation of modern astronomy is well known and does not require a detailed description here.

The end of the 15^{th} century meant golden years for the Academy. From the 16^{th} till the middle of the 18^{th} century, astronomy in Cracow was in a state of permanent decline and became reduced in practice to astrology. An exception to this was the relatively short period when a professor of mathematics and later rector of the Academy became the most famous Polish mathematician of the 17^{th} century: Jan Brożek (Jan Broscius, 1585-1652). He is remembered in the history of science as the first researcher of Kopernik's life and the propagator of his work.

Hundred years later, Polish astronomy reached again a high level thanks to Jan Heweliusz (Johannes Hevelius, 1611-1687). The son of a wealthy brewers' family with Czech-German background living in Gdańsk, he became interested in astronomy early at high school. As the expected future manager of the family business, he was sent to complete his law studies at Leiden University and to pay longer visits in England and France, where he had the opportunity to meet some of the distinguished representatives of the European science, such as the Huygens family, John Wallis, Pierre Gassendi and others. After returning to Gdańsk, where he spent the rest of his life, he took an active part in the municipal administration, becoming a leader of the beer brewing guild and a town councilor.

His main interest, however, remained astronomy. In 1641 he built his

Figure 1. Mikołaj Kopernik in his Frombork observatory. Painting by Jan Matejko (1838-1893).

private observatory on the specially adapted roofs of his three neighboring houses in Gdańsk. The observatory was equipped with excellent instruments of his own making. The most renowned was a refractor (45m focal length, 12cm diameter) used for observations of celestial bodies. The other instruments, measuring stellar positions, were of old, "naked-eye" type, but of a precision comparable to that attainable with refractors. Heweliusz' observatory was certainly the finest observatory in the world at that time and the results it produced were enormous. In 1647, Heweliusz published his most famous work, *Selenographia*, containing 60 carefully executed drawings of the Moon's surface and the first description of the Moon's libration in longitude. This work marks the beginning of lunar topography.

The discovery and motions of six comets were described in *Prodromus cometicus* (1665) and in *Cometographia* (1668). The results of very precise measurements of the positions of 1564 stars were published in *Catalogus Stellarum Fixarum* (1687). Heweliusz observed sunspots and, from these observations, he determined the solar rotation period with surprisingly good accuracy, much better than it was done before. He also left a lasting trace in astronomical nomenclature, devising the term *faculae* for the bright regions surrounding the sunspots, naming "Mira" the variable star *o* Ceti, and, in his sky atlas *Firmamentum Sobiescianum* (1690), introducing several new constellations which are still in use today (*Canes Venatici, Lacerta,*

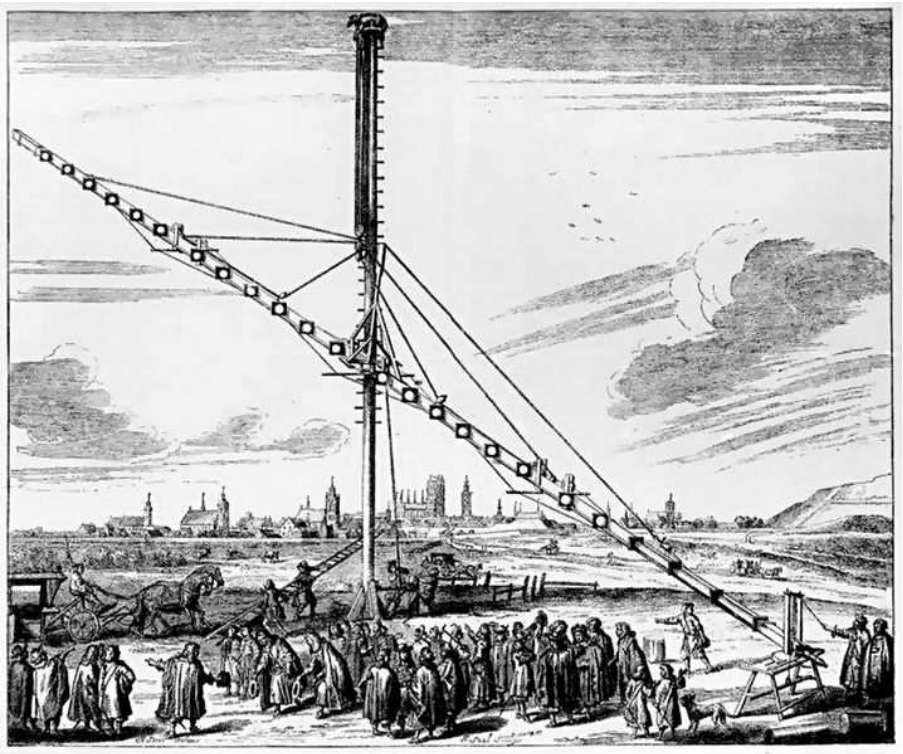

Figure 2. Heweliusz' giant telescope (focal length of 45m).

Sextans, Leo Minor, Vulpecula, Lynx and *Scutum*). He was a precursor of observations of visual double stars and was the first to use a pendulum for time measurements in astronomical observations.

Heweliusz's astronomical work was soon broadly recognized in Europe. He was elected the first foreign member of the Royal Society of London in 1664 and was offered in 1966 the directorship of the newly organized Paris Observatory. Although he declined the offer, King Louis XIV granted him financial support for eight years. Steady support was coming from the Polish Kings of that time, in particular from Jan III Sobieski (1629-1696) who funded in 1677 his lifelong salary and endowed his brewery with many lucrative commercial privileges. In return, Heweliusz depicted the constellation *Scutum Sobiescii* in a shape of the Sobieskis family coat of arm: the empty shield with a cross added to commemorate the victorious battle of Jan III over the Turks in 1683 near Vienna.

In the 17^{th} century, Poland was a multinational country. In particular, its northern part was populated by people of German, Polish, Dutch, Prussian origin. A good example may be Heweliusz himself, who independently of

his complicated ethnic roots considered himself as being – in his own words – *civis Orbis Poloniae*, *i.e.* citizen of the Polish world.

When talking about Heweliusz, it is impossible not to mention his second wife Elisabeth Koopmann (1647-1693), daughter of rich Gdańsk merchants of Dutch origin. Thirty six years younger than her husband, she assisted him in all astronomical observations, and after his death completed and published three of his important works. In the Polish tradition she is considered one of the first, if not the first, female astronomer.

The observatories of Kopernik and Heweliusz were fully private initiatives unrelated to any scientific center. A more general interest in astronomical research was renewed in Poland in the mid-18^{th} century. The growing astronomical knowledge in the period of Enlightment necessitated the creation of observatories as separate university units.

The first university observatory in Polish territory was organized in Wilno (now Vilnius, Lithuania) where King Stefan Batory (1533-1586) raised the old Jesuit's College to the rank of university in 1579. The observatory was then set up in 1753 by Tomasz Żebrowski (1714-1758), professor of trigonometry and astronomy. Systematic observations were started by Marcin Poczobutt-Odlanicki (1728-1810). A former student of astronomy in Italy and France, nominated to be Royal Astronomer by the last King of Poland Stanisław August Poniatowski (1732-1798), after having ordered modern astronomical instruments from Ramsden and Dollond, he started astrometric observations of stars, planets and newly discovered asteroids. His results served Lalande for the correction of the orbit of Mercury. Scientific activity at Wilno observatory continued, including after the partition of Poland in 1795, by other distinguished astronomers: Jan Śniadecki (1756-1830) and Piotr Sławiński (1795-1856). In 1832, the Russian government closed Wilno University as a repression after the November uprising of 1830, but the observatory remained, subordinated to the Academy of Sciences in Petersburg, till 1876 when a fire destroyed it almost completely; the instruments saved and the valuable library were moved to Pulkovo Observatory.

The Stefan Batory University in Wilno came back to life in 1919. The reactivation of the observatory was undertaken by Władysław Dziewulski (1878-1962). It started from nothing, but in the mid-1930s became a modern astronomical institution in Poland, concentrating mainly on astrophysical observations and actual problems of stellar astronomy. After the Second World War (WWII), Wilno was incorporated to the Lithuanian Soviet Republic and its Polish astronomers moved to Toruń.

Cracow Academy was recovering from the long-lasting decline thanks to the reforms undertaken in 1780 by the Commission for National Education – the first "ministry of education" in Poland, created in order to modernize the education on every level after a long period of stagnation under the

reign of the Saxon dynasty. Shortly afterwards, fulfilling the old postulate of Cracow astronomers, the decision to build Cracow Observatory was made and necessary funds were provided. The task of organizing the observatory was entrusted to Jan Śniadecki. He was one of the most outstanding Polish astronomers of his time. A student of mathematics and physics at Cracow Academy, he received his PhD degree at the age of 19. As a candidate for a professorship at the Academy, he was sent to Paris to continue studies under the direction of Laplace and d'Alambert. Nominated professor at the Academy in 1781, he broke the old tradition and started lecturing in Polish instead of the previously mandatory Latin. His organizing efforts succeeded and Cracow Observatory was opened in 1792. Its vast observational program covered the typical problems of the observational astronomy of that time, such as the measurements of precise positions of stars, planets, comets and the newly discovered bodies, as also the first observations of periodic light variations of fixed stars.

After the third partition of Poland, Cracow was annexed first to Prussia and later to Austria. The occupants were not interested in supporting the development of Polish science and culture, and the normal activity of the observatory met increasing difficulties. At last, Śniadecki discouraged by growing problems, gave up and left Cracow in 1803, going abroad and then assuming his post in Wilno. The work at Cracow Observatory continued on a limited scale until the First World War, enriching slowly its instrumentation and observational programs. More significant progress followed in the inter-war period under the directorship of Tadeusz Banachiewicz (1882-1954), best known for his theoretical works on matrix calculation (Cracovians) and promotion of the modern program of eclipsing-binary observations. Under German occupation during WWII, Cracow Observatory was not closed, but Banachiewicz was imprisoned for three months in the Sachsenhausen concentration camp, then dismissed from his position and replaced by a German director.

The other scientific and cultural center in Poland was Lwów (now Lviv, Ukraine), where a university was founded in 1661 by the Polish King Jan Kazimierz (1609-1672). However, the astronomical research was marginal till 1907 when the Chair of Astronomy was established. It was not until 1935 that the Chair was expanded to the Observatory under the directorship of Lucjan Grabowski (1871-1941). A modern program of photographic observations of bright stars in three colors was barely initiated when first the Russian invasion in 1939 and then the German occupation after 1941 completely paralyzed the work of the Observatory. After annexion of Lwów to the Ukrainian Soviet Republic, the Polish scientific staff of the Observatory moved to Wrocław.

The scientific tradition in Poznań dates back to the 16^{th} century: in 1519,

the bishop of Poznań founded the *Academia Posnaniensis* where, among other disciplines, mathematics, geography and astronomy were lectured. In 1571, another bishop of Poznań founded the Jesuit's College, which two centuries later, in 1764, set up its own Observatory equipped with astrometric instruments donated by Maria Leszczyńska (1703-1768), daughter of the King of Poland Stanisław Leszczyński (1677-1766), and later the wife of the King of France Louis XV. The actual organizer of the Observatory and its main observer was the Jesuit Józef Rogaliński (1728-1802). Alas, the war waging in the northern part of Poland, the dissolution of the Society of Jesus in 1773, and the partition of Poland which took place shortly after, stopped any scientific activity in Poznań until the beginning of the 20^{th} century.

In independent Poland, Poznań University was established as soon as in 1919 and two years later its observatory started to be organized under the direction of Bohdan Zaleski (1887-1927), a Polish astronomer working previously in Pulkovo in Russia. The equipment of the Observatory was sufficient to develop both classical positional and modern astrophysical observations. WWII stopped any scientific activity of the observatory: Polish astronomers were fired and some of them arrested. After WWII, the Observatory returned to the reactivated Adam Mickiewicz University in Poznań.

Capital of Poland since 1596, Warsaw played for a long time only a limited role in the academic life of the country. Paradoxically enough, Warsaw University was founded by Czar Alexander I only in 1816 after the loss of independence, *i.e.* in the period of general decline of intellectual activities in Poland. In the same year, Franciszek Armiński (1789-1848), a former student of Delambre and Arago, was nominated professor of astronomy. Thanks to his enthusiasm and efficiency in fighting Russian bureaucracy, Warsaw Observatory was officially opened in 1825. Its imposing building was well equipped with modern instruments, comparable to those used at that time in European observatories. The good prospects of the Observatory were promptly shattered by the changing fates of Warsaw University. After the fall of the anti-Russian uprising of 1830 the University was closed down. In 1856 it was partly reactivated as a Polish medical school and in 1862, after adding a few other departments, was named "Main School". Not for long, however. After the January 1863 uprising, all the Polish-speaking schools were closed down and the Main School was replaced with the Russian-speaking Imperial University of Warsaw.

Warsaw Observatory survived all these perturbations, although under Russian directorship and with very limited Polish personnel. Nevertheless, the name of Adam Prażmowski (1821-1885), one of the most distinguished Polish astronomers of the 19^{th} century, should be mentioned. He worked at Warsaw Observatory from 1839 till 1862. He was first engaged in a program

of measuring the length of the Earth's meridian. He was also the author of a useful method of determining the observer's personal error. Later on he became famous for discovering the polarization of the solar corona and for a proof that the corona belongs to the Sun and not to the Moon, as it was generally accepted before. After the 1863 uprising, he left Poland and went to Paris where he devoted himself to constructing excellent optical instruments. Prażmowski was the first Polish astrophysicist.

After the First World War, Warsaw Observatory possessed only its building. Russians retreating from Warsaw had moved all the instruments to Rostov. They were sent back to Poland in 1925, but it was evident that they were then too primitive to allow any modern observational program. As a consequence, the activities carried out at the observatory were mainly theoretical, concentrating on issues of celestial mechanics. At the same time, a new astrophysical observing station was built in the East Carpathian Mountains at Pop Iwan (2020m above sea level). A 33cm Grubb Parsons astrograph was installed in 1937 and the first photographic observations were initiated. The station was never completed. A Russian invasion in September 1939 led almost immediately to its total destruction. Under German occupation, Warsaw University was closed, as all Polish educational institutions at a level higher than primary schools. The observatory surprisingly survived, but under German commissary directorship. However, it did not escape its fate as, in the first days of Warsaw's uprising in August 1944, it was bombarded by German tanks and burned down together with all its instruments, archives and rich library.

About 30 professional astronomers were working in Poland just before WWII. Almost one fourth of them died in the period 1939-1945. After WWII, Polish astronomy faced a new political situation and an urgent necessity for restoring its material equipment and human resources.

Cracow Observatory avoided severe losses and resumed relatively easily its pre-war activity under the direction of its former director Tadeusz Banachiewicz.

Wrocław Observatory, formerly a part of the German Friedrich-Wilhelms University, happened to survive WWII in surprisingly good shape and resumed its activity already in 1945, under the directorship of Eugeniusz Rybka (1898-1988) with astronomers from Lwów as scientific staff.

In Toruń, the new Nicolaus Copernicus University was created in 1945 and shortly after, in 1948, an observatory was set up in Piwnice near Toruń by Władysław Dziewulski and Wilhelmina Iwanowska (1905-1999).

Warsaw Observatory, which suffered most during WWII, was reactivated in 1950 under the directorship of Włodzimierz Zonn (1905-1975). In 1953, Stefan Piotrowski (1910-1985) initiated the Working Group for the Central Astronomical Observatory, which in 1957 was expanded into the

Institute of Astronomy of the Polish Academy of Sciences, intended to be a scientific center of leading astronomical research in Poland. Both these institutions, working very closely, succeeded in creating the "Warsaw school of astronomy". Its most prominent representative was Bohdan Paczyński (1940-2007), a brilliant theoretician, well known for his pioneering work in theory of stellar structure, evolution of single and binary stars, structure of the thick accretion disks, as well as for inventing the new method of investigation of low-mass objects using the phenomenon of the microlensing of starlight, the correct interpretation of the γ bursters, and many other achievements in modern astrophysics. From 1981, after the imposition the martial law in Poland, he lived in the United States working at the Princeton University.

2. Management and Funding of Higher Education and Research

There are currently about 61,000 research workers and academics employed in Polish educational and research institutions. Of these, 38,000 work as academics in Higher Education Institutions (HEI), 4,500 in institutes of the Polish Academy of Sciences (PAS), and the rest in Research and Development Institutes. About 20% of those workers do research in natural and exact sciences, of which about 1.5% are astronomers.

2.1. HIGHER EDUCATION

The lion's share of the public HEI funds is financed by the national budget. The figure for 2012 is at the level of 2.5 billions euros. All public money spent for research and higher education is distributed by the Ministry of Science and Higher Education (MSaHE). Public HEIs receive a financial support proportional to the size of academic staff and the number of under- and postgraduate students.

The Polish Constitution guarantees free education at all levels, which means that regular students at public HEIs pay no tuition fees. On the other hand, the public HEIs have a right to determine the enrollment level and to accept only the best candidates. All other candidates can attend either extramural or evening study programs at the public HEIs or go to private HEIs. In both cases, they must pay the tuition fees. After a system restructuring in 1989, the need for higher education increased enormously among young people. The number of students raised sharply, reaching almost two millions in 2009, a fivefold increase compared to the end of the 1980s. The public HEIs could not afford to fulfill this need although they accepted about 3-4 times more students than earlier. The pressure from young people resulted in the creation of a large number of private HEIs, virtually out of nothing. Their managers hired academics from the pub-

lic HEIs as a second (third, fourth ...) job, rented classrooms after hours and opened programs almost exclusively in humanities and social sciences. No libraries, no laboratories, just oral lectures during the afternoons and weekends. There are presently over 300 private HEIs – almost three times more than public ones – although they educate only about a third of all the students. As a result of this boom, the proportion of graduates in the different fields became badly distorted. In 2007, for example, there were 64,000 graduates in pedagogy – many times more than the number of new job openings, but only 40,000 in engineering – less than the demand from industry.

Astronomy can be studied from the first year at 6 universities: in Warsaw, Cracow, Poznań, Toruń, Wrocław and Zielona Góra. The total number of graduates in astronomy is 20-30 per year. In agreement with the Bologna process, majors receive BSc degree after 3 years and MSc after an additional 2 years. Separate graduate studies in astronomy exist in the Nicolaus Copernicus Astronomical Center of PAS and in the Astronomical Observatory of the Warsaw University. Joint graduate studies in physics and astronomy are conducted in Cracow, Toruń, Wrocław and Zielona Góra. About 10 students receive PhD degree every year, of which perhaps a half find jobs as scientists, usually after the post-doc stay at a foreign astronomical institution. Less successful graduates and PhD holders in astronomy have no problems in finding jobs in banking, computer centers, as school teachers etc.

2.2. RESEARCH

As in many other countries, the financing of research comes from three main sources: the state budget, the industrial sector and international means. In 2011, the approximate figures were: 1.1 billion euros came from the state budget, the industrial sector provided 1 billion euros, and 0.8 billion euros came through international means, mostly from the European structural funds. All three funds together amount to 0.7% of the Gross National Product, which is quite far from the Lisbon strategy target and places Poland in the tail of European countries.

Research funding goes into three major parts. The first one is core funding, directed to institute directors or deans of faculties. It depends but very weakly on the category given to each unit based on the assessment of its scientific achievements. Otherwise it depends on the size of the unit and on the level of the funding during the previous years. About half the budget money is distributed in this way. This is the largest and most important part of financing for the PAS institutes carrying out research in basic sciences and humanities. Basic salaries and most of the current spending in

these institutes are covered by the core funding.

The second major part of the finances is received from two granting agencies: the National Science Centre (NSC) awards grants in basic sciences and the National Centre for Research and Development (NCRD) does it in applied sciences. Grants from NSC are directed to individual scientists acting as PIs for the planned projects. Following a peer review process, the best projects are selected and approved. Roughly about one fourth of the applications are successful. Due to a low share of the total research funding distributed through grants, the granted amount of money is very modest. It is not sufficient to hire young scientists or to buy more expensive equipment and is usually spent for inexpensive auxiliary instruments, like personal computers, short visits to conferences or to outside scientific institutions (*e.g.* for carrying out astronomical observations) and low supplementary honoraries for the investigators.

The grant money is at the disposal of the grantee, apart from some overhead expenses, being however submitted to possible restrictions from the grant conditions. Substantially higher grants are awarded by the NCRD. Here consortia of research groups or institutes with the industrial enterprises can apply for a partial financial support of the proposed project, provided that the rest comes from industry. In addition to the scientific value, the assessment process includes the estimate of the usefulness of the project for the future development of the Polish economics and the agreement with the priorities specified in the development perspectives.

The third significant part is devoted to the investment in large scientific infrastructures. Applications from individual institutions or consortia are directed to the Minister, who grants the budget money to the successful applicants, following the assessment process. Funds from three operational programs of the European Union (Innovative Economy, Infrastructure and Environment, and Human Capital) are distributed in the same way. By the end of 2011, the Minister had approved the membership of Poland in two large astronomical infrastructures from the European Strategic Forum for the Research Infrastructures (ESFRI) list: the Cherenkov Telescope Array (CTA) and the Low Frequency Array (LOFAR), applicable also in environmental sciences. Poland has just joined the European Space Agency (ESA). The astronomical community hopes that Poland will also join the European Southern Observatory in a near future.

2.3. FOUNDATION FOR POLISH SCIENCE

A very special role in management and funding of research in Poland is played by the non-governmental organization Foundation for Polish Science (FPS), formed in 1991. Its yearly budget consists of only about 1%

of the state budget, but its influence on the quality of Polish research is much higher. Following its principle "Supporting only the best so that they can become even better", the Foundation runs several programs focussed exclusively on outstanding individuals. The subsidies are awarded on the basis of their past achievements, assessed within the peer review process including foreign referees and according to the best international standards. The competition is severe but winning it is highly valued among the scientists. The prestigious FPS Prize is awarded every year to four scientists from four different research fields. Three astronomers have so far received the prize in exact sciences: Alex Wolszczan in 1992 for the discovery of the first extrasolar planetary system, Bohdan Paczyński in 1996 for inventing and implementing a new method of detecting and investigating low-mass objects (cool stars, substellar objects and extrasolar planets) based on the microlensing of starlight and Andrzej Udalski in 2002 for the revision of the distance scale of the Universe and the detection of many candidates for extrasolar planets with the use of the microlensing technique. The approach of FPS to the funding of research often serves as a good example to other institutions managing science, including the Ministry.

2.4. COPERNICUS FOUNDATION FOR POLISH ASTRONOMY

It was founded in 1990 by a group of Polish astronomers. Its main purpose is to support all scientific initiatives in Polish astronomy and to initiate actions serving the consolidation of astronomical community in Poland. The Foundation fulfills its goals through supporting financially the creation of instrumental basis of astronomical institutions, awarding stipends for young researchers, helping astronomers in their personal problems, and supporting popularization of astronomy. The Copernicus Foundation is also the publisher of the international quarterly journal *Acta Astronomica*.

3. Astronomical Institutions

There are currently about 250 professional astronomers in Poland, most of them working in two PAS institutes and six separate astronomical institutes within HEIs. The rest is dispersed in smaller units usually within institutes of physics. As to the productivity of Polish astronomers, the total number of scientific publications per year is at the level of other countries with comparable numbers of scientists, but their quality is relatively higher: according to the Thomson Reuters Institute for Scientific Information, the citation rate of the papers with the Polish authors/coauthors is about 1.2 times the world average[1].

[1] http://archive.sciencewatch.com/dr/sci/11/jan23-11_1/

3.1. NICOLAUS COPERNICUS ASTRONOMICA CENTER OF PAS (NCAC)

NCAC[2] is the largest astronomical institute in Poland, with its headquarters in Warsaw and a subsidiary in Toruń. Altogether 36 scientists work at NCAC, of which six in Toruń. In addition, there are between 15 and 20 graduate students completing their PhDs. The research fields include high-energy astrophysics, cosmology and gravitation, nuclear astrophysics and physics of condensed matter, variable stars, star clusters, star pulsations, physical processes close to black holes, circumstellar disks, dynamics of stellar systems and planet search. The international cooperation is concentrated around large-infrastructure facilities such as CTA and HESS (High-Energy Stereoscopic System), both measuring high-energy γ rays, or the 10m South African Large Telescope (SALT). NCAC astronomers are members of teams carrying out some of the cosmic experiments, like Integral, Herschel or Brite-PL (the Canadian-Austrian-Polish project for observations of stellar pulsations with the use of six photometric nanosatellites). A permanent cooperation with French astronomers takes place within the frame of a special Polish-French program, funded by both sides. Occasional collaboration takes place with astronomers from several leading astronomical institutions, like Princeton, Harvard, Oxford, Cambridge and many others. Worth mentioning is the new program Solaris, aimed at the accurate spectroscopic observations of binaries with four small-size, automated telescopes distributed around the world.

3.2. ASTRONOMICAL OBSERVATORY OF THE JAGIELLONIAN UNIVERSITY

Cracow Observatory[3], the institution with the most notable astronomical tradition, is presently part of the Faculty of Physics, Astronomy and Applied Informatics. There are 24 academics employed at the Observatory. A number of small radio and optical telescopes are located at Fort Skała Observatory in the outskirts of Cracow. The main scientific programs include high-energy astrophysics, investigation of active galactic nuclei, diffuse matter, binary stars, galactic magnetic fields and radio monitoring of the Sun. The Observatory is involved in exploiting large facilities such as HESS, CTA, LOFAR and SALT.

There is another small, yet worth mentioning, group of astronomers in Cracow. Nine academics are employed in the Astronomy Chair within the Institute of Physics at the Pedagogical University[4]. They have a small observing station with a 60cm optical telescope located at the top of Mount

[2]http://www.camk.edu.pl/
[3]http://www.oa.uj.edu.pl/
[4]http://www.as.up.krakow.pl/

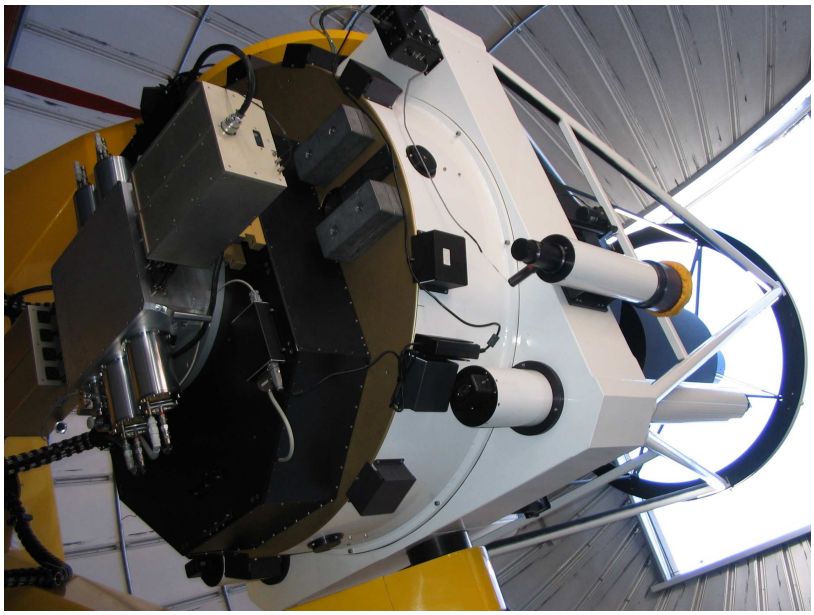

Figure 3. Warsaw 1.3m telescope in Las Campanas with its 32 chip CCD camera of the OGLE project.

Suhora in the Western Carpathian Mountains, 1000m above sea level, which is a relatively good astronomical site for Poland. The main research activities concentrate on observing variable stars, mostly pulsating and eclipsing binaries. The telescope is a part of the Whole Earth Telescope, used for obtaining long, uninterrupted observational runs of selected stars.

3.3. WARSAW UNIVERSITY OBSERVATORY

Warsaw Observatory[5] is organizationally part of the Faculty of Physics, but in practice has a great deal of autonomy. Its present academic staff comprises of 18 astronomers. It has the right of awarding PhD degrees in astronomy, and the degree of *doctor habilitatus*. The observatory conducts astronomical studies at undergraduate and graduate levels for about 70 students.

The equipment of the observatory consists of a 60cm reflector located at an observing station near Warsaw, used mainly for educational purposes, and a 1.3m reflector located in the Southern Hemisphere, at Las Campanas Observatory of the Carnegie Institution of Washington. The latter telescope is dedicated to the long-term project of massive stellar photometry OGLE

[5] `http://astrouw.edu.pl/`

(Optical Gravitational Lensing Experiment), since 1992 regularly bringing top quality scientific discoveries and providing a rich observational basis for research in many fields. The other long-term sky survey, ASAS (All Sky Automated Survey), monitoring stars brighter than 14 mag, is using an array of small CCD cameras located at two stations: Las Campanas, Chile, and Haleakala, Hawaii.

Warsaw astronomers are involved in international collaborations such as ARAUKARIA, HESS, CTA, LIGO/VIRGO as well as in the satellite missions PLANCK and GAIA. Theoretical activities concentrate on broad fields of modeling stellar pulsations and evolution of stars and stellar systems.

3.4. ASTRONOMICAL OBSERVATORY OF THE ADAM MICKIEWICZ UNIVERSITY

This observatory[6] is part of the Faculty of Physics at Adam Mickiewicz University in Poznań and employs 17 academics. A few small instruments are located at Borowiec observing station, near Poznań. The main scientific interests deal with traditional areas of research at the Observatory, *i.e.* classical astronomy. In particular, specific programs are concentrated on fundamental astrometry, dynamics of small bodies in the Solar System and dynamics of artificial satellites. Recently, the scientific scope has been broadened to stellar astrophysics, with the investigation of binary stars as a main subject.

3.5. CENTRE FOR ASTRONOMY OF THE NICOLAUS COPERNICUS UNIVERSITY

The Centre for Astronomy[7] is a part of the Faculty of Physics, Astronomy and Applied Informatics at the Nicolaus Copernicus University in Toruń. The university was formed after the WWII by academics from the former Stefan Batory University. There are 17 academics working presently in the Centre (of which six are radioastronomers) and 16 members of engineering staff.

The Centre is located in Piwnice, a village 15km north of Toruń. The site contains a 32m radio telescope and a few optical instruments, among which a 90cm Schmidt-Cassegrain telescope and a 60cm photometric telescope. The optical telescopes are used mainly for student training and modest research projects.

The main research topics include: search for extrasolar planets, dynamics of planetary systems, physics and chemistry of interstellar matter, variable

[6] http://www.astro.amu.edu.pl/
[7] http://www.astri.uni.torun.pl/

Figure 4. Toruń 32m radiotelescope.

stars, late stellar evolutionary stages, cosmic magnetism, active galactic nuclei, radiospectroscopy, cosmology, high-energy astrophysics and computational astrophysics.

The Centre for Astronomy is involved in international collaborations such as the VLBI network, HESS, SALT, and in collaborations with a number of astronomical institutions, including Jodrell Bank Centre for Astrophysics, Manchester University (radioastronomy), Penn State University (planet search) and the University Observatory in Munich (cosmic magnetism).

3.6. ASTRONOMICAL INSTITUTE OF THE WROCŁAW UNIVERSITY

The institute[8], part of the Faculty of Physics and Astronomy, is hosting 18 academics and about 10 graduate students. Research is being done on

[8] http://www.astro.uni.wroc.pl/

two main subjects: investigation of the solar activity and of variable stars, mainly pulsating, using the asteroseismology technique.

The main local facilities, a 53cm coronograph and a 60cm optical telescope, are located at Białków observing station near Wrocław. The institute is involved in analyzing data obtained from cosmic experiments such as Yohkoh, DOHO, TRACE, RHESSI, CoRoT and Kepler. The staff members collaborate with astronomers from various foreign institutions in Austria, Belgium, Bulgaria, the Czech Republic, France, Slovakia and the United Kingdom.

3.7. INSTITUTE OF ASTRONOMY OF THE ZIELONA GÓRA UNIVERSITY

This is the youngest astronomical institute[9] in Poland, founded in 2000. Professional astronomical activity had however started at Zielona Góra Pedagogical University in 1988. The institute belongs to the Faculty of Physics and Astronomy and employs 12 academics. Their research mostly deals with investigations of pulsars, neutron stars (including their magnetospheres), black holes, high-energy astrophysics, celestial mechanics and planet search. The Institute cooperates with a number of foreign institutions in Germany, UK, USA, France, Holland, Japan, India Australia and China. The Institute is involved in POLFAR (Polish LOFAR) and POLGRAV international projects.

3.8. SPACE RESEARCH CENTER OF PAS (SRC)

SRC[10] has its headquarters in Warsaw and two divisions in Poznań and Wrocław. There are 44 scientists employed in SRC, but only a fraction of them do research in astronomy, more precisely in solar physics, planetary science, comets, interplanetary medium and cosmic weather. All Polish instruments flown in cosmic experiments have been built at SRC. The first of two nanosatellites for the program Brite-PL (see above) has also been built there. Astronomers from SRC take (or have taken) part in important international cosmic programs such as Cassini, Integral, Herschel, Rosetta, Brite-PL, a number of solar experiments (including Solar Orbiter) and others. The possibilities for space research will increase substantially when Poland joins ESA, hopefully very soon.

[9] http://www.astro.ia.uz.zgora.pl/
[10] http://www.cbk.waw.pl/

4. Professional and Amateur Organizations

4.1. COMMITTEE FOR ASTRONOMY OF THE POLISH ACADEMY OF SCIENCES

PAS' Scientific Committees were formed at the same time as the Academy which replaced in 1952 the traditional learned society, The Polish Academy of Arts and Sciences existing, under different names, since 1815. The main duties of the Committee for Astronomy[11] are to represent the professional astronomical community in outside relations, to assess new research initiatives, particularly those involving substantial funding, to report periodically to the PAS authorities on astronomical activities and to express its opinion about candidates to PAS membership. The Committee also acts as the National Committee for the International Astronomical Union. It is a body of about 30 members, elected every four years from among astronomers holding at least the habilitation degree, supplemented by the PAS members who are the Committee members *ex officio*.

4.2. POLISH ASTRONOMICAL SOCIETY

The Polish Astronomical Society[12] was founded in 1923 on the 450^{th} anniversary of the Copernicus birth. It is a society of professional astronomers, although many graduates in astronomy not working actively in scientific institutions are also members. Currently the society gathers together about 250 members.

The society aims mainly at promoting astronomy as well as the cooperation with educational institutions on astronomy programs in high schools and the popularization of science. Every two years, the Society holds a meeting in one of the astronomical institutions of the country. The program consists of a scientific session with invited and contributed papers (plus a poster session) and a general assembly dealing with administrative matters and the election of a new executive committee. Between 1953 and 1998, an advanced popular journal *Postępy Astronomii* (Progress in Astronomy) was published by the society. The society awards three prizes: the Paczyński Medal for the best research achievements, the Young Astronomer Prize to the best research achievements by a young astronomer and the Zonn Prize for outstanding popularization of astronomy.

[11] http://www.ka.pan.pl/
[12] http://www.pta.edu.pl/

4.3. POLISH AMATEUR ASTRONOMICAL SOCIETY

The Society[13] was founded in 1919 as an organization of amateurs and astronomy enthusiasts who wanted to promote the knowledge on the Universe and to actively participate in simple observational programs. Presently several hundred people, mostly high-school students, are members of the Society. It has 16 subsidiaries covering the whole country. They currently carry out observational programs including observations of comets, meteorites, planets, transits, Sun and variable stars. Some of the groups use sophisticated instruments and produce valuable results. Between 1922 and 1998, a popular journal *Urania* was published by the society. Since 1998, the journal is published together with the Polish Astronomical Society under the title *Urania – Postępy Astronomii*.

5. Concluding Remarks

For the last few centuries the Polish astronomy shared ups and downs of the whole country. The Polish soil was a battlefield in innumerable wars sweeping the country at almost every generation. Whenever the people recovered from the disaster and tried to organize a new life, the next war destroyed everything again. This has changed after World War II. The post-war period is perhaps the longest peaceful time in the recent history of Poland. Although its major part was spent under the communist regime, the scientific community had been gradually regenerated. Astronomy was more fortunate than *e.g.* social sciences because it was not considered as potentially dangerous for the ideology in power. At small concessions (like appreciating the leadership of the Soviet science) astronomers were permitted to contact Western colleagues, to attend international conferences (although without any financial support from the State) and to spend extended periods of time at American and West European observatories. The professors who organized the Polish astronomical institutes after the WWII were aware of the necessity for close collaboration with the world community. Thanks to them, almost all present professors went as young postdocs to world leading scientific institutions. That quickly benefited to Polish astronomy, allowing to approach a world level of research. It should also be stressed that several Western (most notably American) scientific organizations and institutions helped us materially in the early post-war years by providing scientific literature and some instruments to the Polish observatories. This enabled teaching new generations of scientists and doing valuable research.

The prospects for the further development of astronomy in Poland are promising. At present, one does not see any threat to a prosperous future

[13] `http://www.ptma.pl/`

of the country. If only state authorities understand that further progress is conditioned on generous financing of the best research, the Polish astronomers can look optimistically into the future.

Acknowledgements

The authors are grateful to anonymous referees for their suggestions and linguistic improvements brought to the paper.