

Astronomy in the Czech Republic

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A brief historical outline of the development of astronomy in the Czech lands is presented, followed by an overview of the current observational, research and educational facilities.

Historical development

In the Czech lands, astronomy has rather deep roots, covering at least all the last millenium. A significant milestone for pursuing astronomy in Bohemia and surrounding countries was represented by the establishment of the University in Prague by the Emperor Charles IV in 1348. Astronomy, as one of the seven liberal arts, was greatly emphasised right from the beginning of the lectures, and Prague University soon began to support the creative development of astronomical knowledge brought especially from Paris, Oxford and other places in Europe. It reached a remarkable level, e.g. in widely spread treatises “On the construction and on the use of the astrolabe” by Cristannus de Prachaticz (1407) or in the design of the Prague Astronomical Clock (1410) by Johannes Schindel.

The most famous era of astronomy in Prague was probably the period of rule of the Emperor Rudolph II at the turn of the 16th and 17th century, when Tycho Brahe and Johannes Kepler dwelt and worked at the Emperor’s court. The fact that Brahe, and later also Kepler, came to Prague, as well as Kepler’s success achieved in this city, were not a result of some lucky coincidence or the Emperor’s generosity and eccentric nature. To a great degree, these were logical consequences of the gradual development of Prague’s cultural and scientific environment. It was mainly Tycho’s friend Thaddaeus Hagecius, who prepared the grounds for Tycho’s arrival. Hagecius was the Emperor’s physician, and at the same time one of a few European astronomers of that time, who, like Tycho Brahe, studied the skies with a critical scientific approach. It was in Prague where Kepler found, during his stay in the years 1600–1612, his first two laws of



Photo: P. Hadrava, Astronomical Institute, Academy of Sciences of the Czech Republic

Figure 1: The Astronomical Clock in the Old Town of Prague.

planetary motions, while evaluating the positions of Mars observed by Tycho Brahe. He published numerous treatises, among them “Astronomia nova” including the laws of planetary motions, texts on the “New Star” of 1604 in the constellation Ophiuchus, and he wrote his first version of “The Dream, or Posthumous Work on Lunar astronomy” on the astronomy viewed from the surface of the Moon.

After the Thirty Years War, education was predominantly provided and controlled by the Jesuit order. Astronomy, as well as other sciences, was pursued mainly in the Clementinum College in Prague. In 1722 the Astronomical Tower was built there. Thanks to the care of the first director of the Clementinum observatory, Josef Stepling, the Astronomical Tower was equipped with new instruments around 1750, becoming the first state-supported astronomical observatory in Czech lands.

The advance of astronomy went hand in hand with the development of other sciences. Among the important scientific personalities in the 19th century were the mathematician Bernard Bolzano and the biologist Jan Evangelista Purkyně, who studied, besides other things, the



Figure 2: New star of 1572 in the constellation of Cassiopeia from “Dialexis” by Thaddaeus Hagecius (Frankfurt am Main 1574).

physiology of the human eye. Of absolutely crucial importance for the future development of astronomy and other sciences was the idea of the influence of a binary star’s motion on the colour of their light, which Christian Doppler, the professor of the Prague Polytechnic, presented in his lecture held in the Carolinum in 1842. He published his result in a



Photo: I. Král, National Library, Prague

Figure 3: The allegory of sciences on the ceiling fresco in the New Mathematical Hall in Prague Clementinum. It shows the Clementinum Astronomical Tower along with the extrasolar planetary systems according to Giordano Bruno’s idea of the “multiplicity of worlds” (National Library of the Czech Republic).

local Bohemian journal, consequently his principle was later rediscovered by H. A. Fizeau. In the second half of the 19th century, Ernst Mach contributed enormously to the education of a whole generation of both German and Czech physicists and astronomers. He also helped in the general recognition of Christian Doppler's achievement.

In 1886, the Astronomical Institute of the Charles University in Prague was established by August Seydler, who served as its first director. He elaborated sophisticated methods for determination of orbits of minor planets and wrote textbooks on theoretical physics and many popular articles on astrophysics. In the last decade of the 19th century, Seydler's successor, Gustav Gruss, observed variable stars and carried out visual observations of stellar spectra.

Albert Einstein spent one and a half years (1911–1912) in Prague, being appointed professor at the German Prague University. During his Prague time he published eleven papers, including the first one on the deflection of light by the gravitational field of the Sun, containing the formulation of the first fundamentals of the theory of General Relativity.

There is an interesting connection between astronomy and literature: Jan Neruda (1834–1891), Czech poet, writer and journalist, was born in Prague, and grew up in a colourful part of the town called Malá Strana (Lesser Quarter). His first laurels came from the success of his collection of poetry called "Cosmic Songs" that documented his good astronomical knowledge. The song No. XXII "... are there frogs there, too?" was, on the occasion of the 26th General Assembly of the IAU in Prague, translated by Robert Russel into English. Jan Neruda was godfather of Josef and Jan Frič, the sons of the revolutionary Josef Václav Frič, who were born in Parisian exile. Both brothers shared an interest in astronomy with their godfather. When they came back to Bohemia, they started their astronomical observations, at first with the support of professor Vojtěch Šafařík. Later, they established a factory in Prague, which produced optical devices, and developed astronomical instruments. After the death of younger brother Jan, Josef built an ob-

servatory at Ondřejov near Prague. In 1928, Josef Jan Frič donated his observatory to the state.

After the establishment of the Czechoslovak Academy of Sciences in 1953, the former State Observatory in Clementinum, together with the Ondřejov Observatory, became the basis of the Astronomical Institute of the Czechoslovak Academy of Sciences. One historical root of this institution thus reaches to 1722, when Clementinum observatory was established by the Jesuits, and another to the Frič's foundation of the Ondřejov Observatory in 1898, which was inspired by the interest of his poetic godfather Jan Neruda.

Current Facilities

The Astronomical Institute of the Academy of Sciences of the Czech Republic has a prominent position as the largest professional place in the Czech Republic. The names of the Institute's four scientific departments suggest a lot about its scientific profile: Solar Physics; Interplanetary Matter; Stellar Physics; and Galaxies and Planetary Systems.

The Solar Physics department focuses on active solar phenomena such as sunspots, solar flares and coronal mass ejections. The data coming from the instruments of the Ondřejov observatory, including optical and radio wavebands, are combined with X-ray and UV observations from satellites and space probes

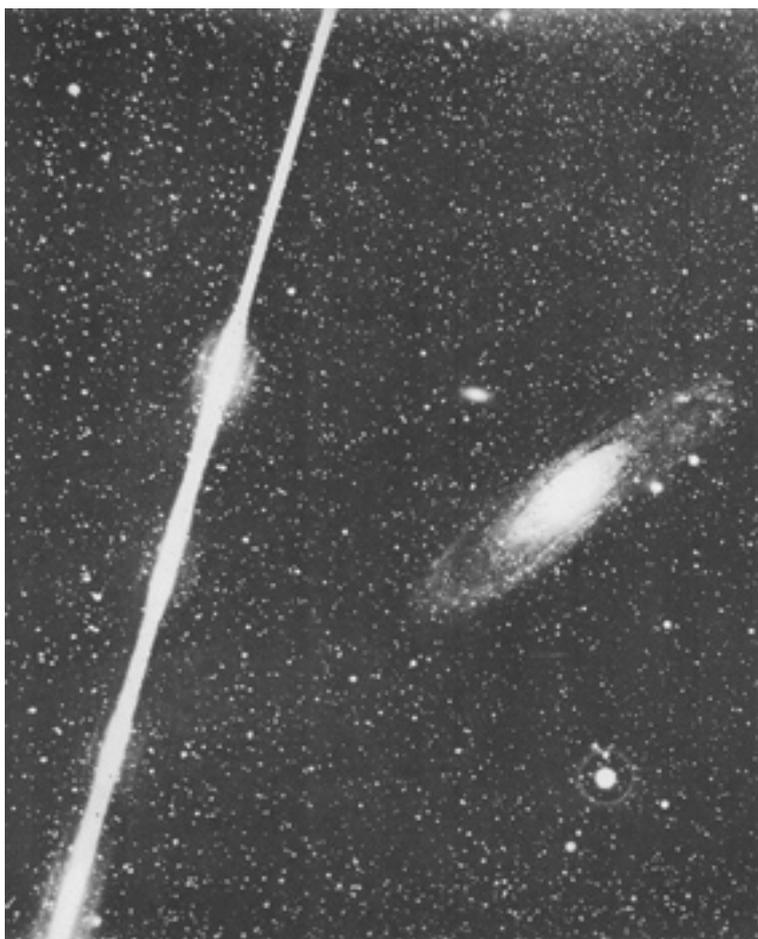
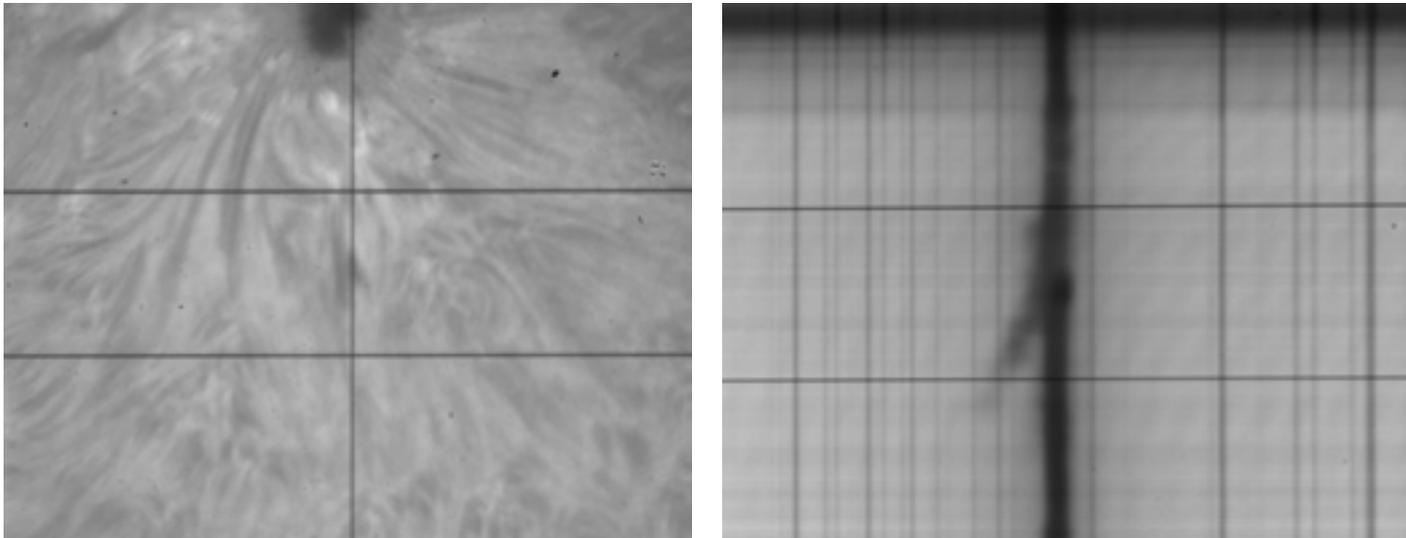


Figure 4: The observation of fireballs has a long tradition at the Ondřejov Observatory. The photograph taken on 12 September 1923 by Josef Klepešta shows the M31 galaxy in Andromeda with a fireball in front.

Figure 5: H α filtergram (left panel) and corresponding H α spectrum (right) of a solar active region as obtained by the Ondřejov large horizontal solar telescope HSFA2 on 4 July 2006. Note the Doppler shifted features in the spectrum (wavelength increasing to the right).



to have a complex multi-wavelength information on these fast non-equilibrium phenomena. The observations are compared to numerical simulations trying to discover the basic mechanisms ruling the Sun. The main goal is the study of magnetohydrodynamic and radiative processes in the solar plasma, which offers conditions unachievable in laboratories on Earth. The Sun-Earth relation and cosmic weather are also studied with a lot of geophysical and other practical applications.

The department of Interplanetary Matter operates the European network of all-sky cameras, which records meteors, particularly the brightest of them, which are called fireballs. This network holds the world's primacy in finding meteorites upon observation of their passage through the Earth's atmosphere. In 1959, parts of the meteorite Příbram were found upon calculation of its path through the Earth's atmosphere based on photographs taken by all-sky cameras. The network of all-sky fireball cameras and spectral cameras has been in continuous operation since 1963 and is currently the only one in the world. The atmospheric fragmentation and structural properties of meteoroids, chemical composition of meteoroids from spectroscopy, physics of meteor radiation and ionisation, and long-term activity of meteor showers from radar observations, are studied. In 1993 a new programme of CCD observations of asteroids using a dedicated 0.65-m telescope started with the focus on their

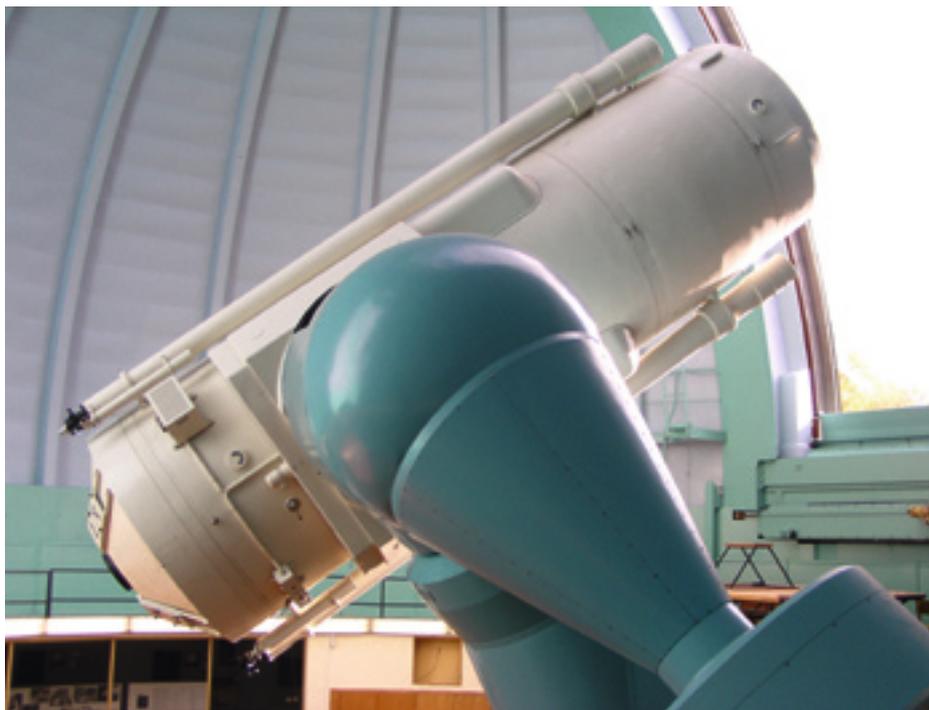


Figure 6: The 2-m telescope in Ondřejov.

rotation and the detection of near-Earth asteroids. In recent years, new discoveries have been made of several binary and very rapidly rotating asteroids.

The Stellar Physics department operates the largest telescope on the territory of the Czech Republic, which has a primary mirror of 202 cm diameter. The main focus is on the study of variable, espe-

cially binary stars. The photometric and spectral observations are combined to disentangle the orbital parameters of binaries. The use of spectroscopy requires the development of the theory of stellar atmospheres, as well as other methods of processing and evaluation of observational data. Interacting binaries are usually strong sources of X-ray radiation as observed from space probes.

Photo: J. Havelka, Astronomical Institute, Academy of Sciences of the Czech Republic

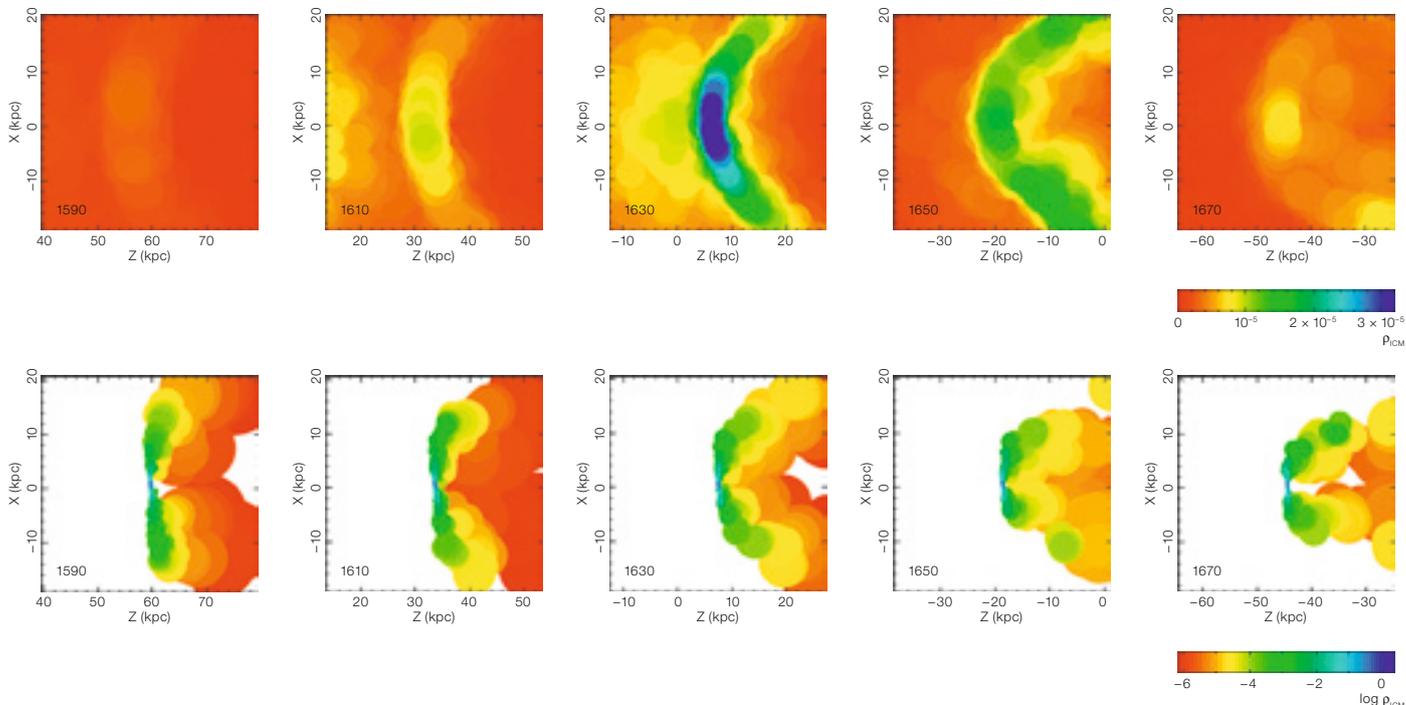


Figure 7: Gas stripping in galaxy clusters: formation of a bow shock in front of a galaxy as seen in simulations using N-body SPH with a gravity tree code. From Jáhym, P., 2006, Ph.D. Thesis, Charles University Prague, and Université Pierre et Marie Curie, Paris.

The department of Galaxies and Planetary Systems resides in the Prague part of the Astronomical Institute, but it has its own zenith telescope in Ondřejov. It deals with the study of the rotation of the Earth, and with the theoretical problems of Solar System dynamics and exoplanets. The trans-Neptunian bodies are studied including the resonance in the Kuiper Belt. Triggered star formation in the turbulent interstellar medium is studied both in observations and simulations. The influence of gas recycling on galaxy evolution across a Hubble time, including gravitational and hydrodynamic processes, is considered (see Figure 7 for example). Study of relativistic astrophysics includes accretion processes and resonances in discs surrounding black holes. An example is shown in Figure 8 where the predicted variations of the X-ray spectrum of an accretion disc at eight successive phases are plotted during the entire orbit of a single spot located at a distance of seven gravitational radii from the black hole and rotating clockwise. A distant observer is placed at an inclination of 30 de-

grees with respect to the disc normal and sees the system from the left side. Superposition of several tens of such spots then contributes to the source variability as the spots arise, trace some part of the orbit, and gradually fade away (c.f. Eckart et al. 2006).

In the Institute of Physics of the Academy of Sciences of the Czech Republic, a research group participates in the project of the Pierre Auger Observatory which is building an array of telescopes in Argentina to detect showers of high-energy cosmic rays. The contribution of the Czech Republic includes mainly the fabrication of hexagonal mirrors for two the Schmidt cameras observing Cherenkov radiation in the Earth's atmosphere.

The Astronomical Institute of the Charles University, which is an integral part of the Faculty of Mathematics and Physics, has mainly educational duties in teaching undergraduate and graduate courses of astronomy and astrophysics. The research areas include the spectroscopic properties of hot stars, particularly in binaries and multiple systems, and exploration of the nature of Be stars. Studies of physical properties, dynamics and evolution of small bodies of the Solar System include the Yarkovsky effect and

observations mainly deal with orbits and light curves of asteroids, including new discoveries of such bodies. Studies in cosmology, with special emphasis on the properties of gamma-ray bursts, are performed. Studies in history of astronomy focus particularly on the Bohemian region.

The Institute of Theoretical Physics of the Charles University is also a part of the Faculty of Mathematics and Physics. Students are educated in mathematics and computing, and in theoretical physics, including classical and quantum mechanics, elementary particle physics, thermodynamics, relativistic physics and cosmology. Research areas include gravitational collapse with small non-spherical perturbations, black-hole electrodynamics, theory of gravitational radiation, exact solutions of Einstein's field equations and cosmological perturbation theory.

The Institute of Theoretical Physics and Astrophysics at the Faculty of Sciences, Masaryk University in Brno, provides basic courses in astronomy and astrophysics at the undergraduate and graduate level. Research includes the physics of hot stars, non-LTE models of stellar atmospheres, variable stars, carbon stars, K-type giants and properties of atmos-

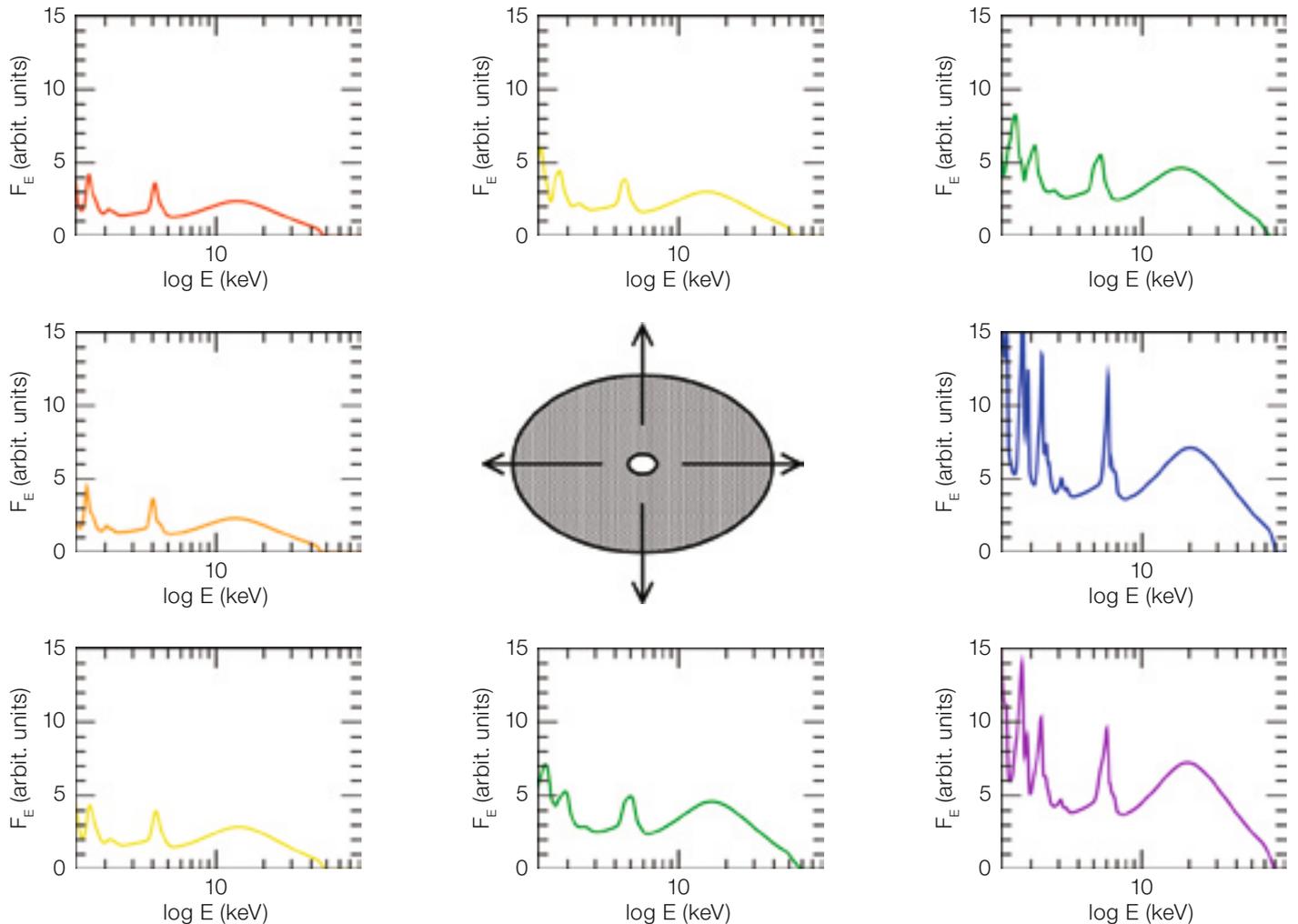


Figure 8: The predicted variations of the X-ray spectrum of an accretion disc around a galactic nucleus black hole are plotted. (From Goosmann R. W. et al., in "The X-ray Universe 2005", edited by A. Wilson, El Escorial, Madrid, Spain, in press.

pheric extinction. The Institute manages the Masaryk University Observatory at Kraví hora equipped with a 0.6-m reflector with a CCD camera.

The Relativistic Astrophysics Group of the Institute of Physics of the Silesian University in Opava is active in the fields of neutron stars, black holes and cosmology. The anisotropies of the CBR are explored as well as Λ -CDM cosmological models.

The Czech Republic can be proud of its unique net of planetaria and public observatories. Their primary goal is to provide natural science knowledge to a broad public and to demonstrate the sci-

entific method by special astronomical research. The Klet' Observatory, which is equipped with a 1-m telescope with a CCD detector, has its research programme dedicated to the astrometry of asteroids with unusual orbits and comets, providing precise determination of their orbits. The main part of the work is devoted to the near-Earth orbits. The data are provided to the Central Bureau for Astronomy Telegrams of the IAU. Other observatories include the Nicolaus Copernicus Observatory and Planetarium in Brno, Štefánik Observatory and Planetarium in Prague, Rokycany Observatory, Úpice Observatory, Valašské Meziříčí Observatory, and others.

This brief review presents the past and current status of astronomy in the Czech Republic, which is the starting point for the entrance of the Czech Republic into ESO.

References

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HAWK-I, the new VLT near-IR camera, assembled and being tested in the ESO Garching instrumentation laboratory.

