With the construction of the Southern African Lagre Telescope (SALT) – an 11 m diameter telescope located at the site of the South African Astronomical Observatory (SAAO) just outside Sutherland – Poland will gain acces to 10% of the observing time of the telescope, able to record distant stars, galaxies and quasars a billion times too faint to be seen with the unaided eye

SALT team

Investigating the Universe at Large

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For 25 years, scientists from the Nicolaus Copernicus Astronomical Center have been investigating the properties of stars and distant galaxies

The Nicolaus Copernicus Astronomical Center (CAMK) is a reasearch institute of the Polish Academy of Sciences (PAN). Founded in 1978, the Centre now employs 38 researchers and teaches 22 PhD students. Its fields of research cover astronomy, astrophysics and cosmology.

CAMK's history dates back to the early 1970s, when Dr Bohdan Paczyński and Dr Józef I. Smak presented a plan to create an institute which would carry out theoretical research in astrophysics. A similar initiative arose in the USA – in 1970, the American National Academy of Sciences (NAS) formed a special committee to honor the 500th anniversary of Copernicus' birth. In 1971 the committee sent a delegate to Poland, Dr. Charles R. O'Dell of Yerkes Observatory. His talks with representatives of the Polish astronomical community and PAN lead to the NAS's acceptance of the institute project. The NAS was able to provide substantial financial aid for the construction of the new institute, without becoming embroiled in political, legal or administrative problems.

At the beginning of the 1970s, Poland owed the US about $351 million for post-war shipments of agricultural products from America to Poland. It became possible to convert the debt into investments made in the construction of the institute. On 6 February 1973, 30.7 million złotys (officially equivalent to $1.6 million) was received from the National Science Foundation. Additional funds required to buy the most important piece of equipment at the Center, a high-speed computer, were obtained thanks to a formal dinner organized by Dr. O'Dell and the American industrialist Albert M. Baer. The event took place at the Hotel Waldorf Astoria and brought in over $130 thousand.

CAMK has achieved a position as a world-class astrophysics center. Among its most important achievements are

works by Bohdan Paczyński. Professor Paczyński, now at Princeton University Observatory and one of the top astrophysicists in the world, began his career at the PAN Astronomy Unit and CAMK. His classic papers from the 60s and 70s, on the evolution of single and double stars, were written during his years in Warszawa. It was then that he developed the theory of the outflow of matter from stars with connective envelopes and filled Roche lobes in binary systems, explained the formation of Algol-type systems, discovered the importance of gravitational radiation for the evolution of close binaries, identified the URCA process as an important factor in defining the temperature of evolved stellar nuclei and developed the theory of thick accretion disks.

CAMK's achievements

Other important achievements include works by Wojciech Krzemiński (currently at the Carnegie Institution Observatories), one of the observers who in the 1960s discovered the binary nature of cataclysmic variables. He and Józef Smak suggested that accretion occurs in these objects and correctly interpreted their light curves as arising from an accretion disk hit by a narrow stream of matter flowing through the inner Lagrange point from the less-massive component of the system. At the beginning of the 1970s, Smak was the first to discover the variations in the size of the accretion disk in the U Gem system, thus providing observational data in support of the theory explaining dwarf novae as arising from disk instabilities. Smak is also one of the researchers who at the beginning of the 1980s discovered the thermal instabilities of the disks in cataclysmic systems.

In 1986, Paweł Haensel and his co-workers derived the first detailed models of strange stars (compact objects wholly or mostly built out of quark matter). In 1989 Haensel and his co-workers obtained a simple and yet very accurate formula linking the rotational angular velocity of a neutron star to the maximum mass and its equivalent static radius. The simplicity and universal application of this formula make it an extremely useful tool for observational differentiation of different equations of state for dense matter. In 1991, Haensel and his team showed that, in contrast to previous estimates, direct URCA processes also occur in very high density matter. This discovery prompted extensive changes in the proposed scenarios for the evolution of young neutron stars.

Wojciech Dziembowski is a world-class expert on stellar pulsations and helio- and astroseismology. At the beginning of the 1990s he and his co-workers used helioseismological data to obtain models of the solar interior which unambiguously demonstrated the correctness of the standard model. He also showed that the discrepancy between the theoretical and observed solar neutrino flux results from the theory of fundamental particles.

Andrzej Zdziarski and his co-workers are widely known for their work on gamma and X-ray radiation from active galactic nuclei (AGN). Zdziarski was one of the first to establish the importance of Compton scattering of AGN radiation from the cold accretion disc. Based on Seyfert-type AGN he showed that the X-ray cosmic background radiation, the nature of which was not known at the time, could arise from the combination of photons from active galactic nuclei.

In 1995, Bożena Czerny presented a model explaining a range of types of X-ray emission observed in AGN. Its basic component is a relatively thin and cool accretion disc enclosed within a much thicker and hotter corona, which, like the disc, can accrete onto a central black hole. Czerny's model adds further arguments for the existence of black holes. It also explains the spectroscopic and photometric properties of binary X-ray sources, in which the major component is a neutron star rather than a black hole.

The most important problem of modern cosmology is the formation of galaxies, galactic clusters and large scale structure visible in the spatial distribution of galaxies and in their velocity field. Roman Juszkiewicz, Franois Bouchet and their co-workers and students from CAMK and the Institut d'Astrophysique in Paris have developed a mathematical formalism which enables them to follow the evolution of the density distribution of the velocity field in an expanding Universe. Juszkiewicz's perturbation methods can be used to improve estimates of the cosmological density parameter "omega" and as a precision tool for probing and interpreting the structure of the Universe in the era of large-scale galactic redshift surveys. At the beginning of the year 2000, Juszkiewicz and his co-workers presented an analysis of the dynamics of pairs of galaxies, showing that the matter density in the Universe is only one third of the critical density at which the Universe would be flat.

Andrzej Sołtan observed correlations between fluctuations in the cosmic X-ray background and the distribution of galactic clusters. This may mean that galactic clusters have halos of very low density hot plasma. If this is confirmed, it will have an important impact on our understanding of the amount and distribution of dark matter in the Universe. Similar correlations have been observed by Sołtan for individual galaxies.

At present the Center carries out research on stellar evolution, the theory of accretion, high energy astrophysics, the dynamics of stellar systems, cosmology, relativity theory, the astrophysics of neutron stars, numerical simulations and other fields, comprising 30 programs funded by the State Committee for Scientific Research and several international projects. CAMK is able to confer Ph.D. and doctor habilitatus degrees. Together with a group from the Space Research Center, CAMK participates in the INTEGRAL satellite mission (http://astro.estec.esa.nl/Integral) and coordinates the Polish involvement in the construction of the 11m diameter SALT telescope in South Africa. ■