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Window to the Universe

The telescopes at the Polish observatory in the heart of Chile's Atacama Desert leverage its extraordinary location to observe the cosmos on an unprecedented scale.

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The Rolf Chini Cerro Murphy Observatory in Chile (also known by the shorter name "Observatory Cerro Murphy" – OCM), affiliated with the Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences, was officially inaugurated on 28 November 2023. Located in the heart of the world's driest desert, this observatory has quickly become a very important site on the global map of astronomical observatories. The region surrounding the OCM is renowned as one of the best locations on Earth for astronomical observations. The OCM is a close neighbor to other prestigious observatories, such as Cerro Paranal (ESO) and the Atacama Large Millimeter/submillimeter Array (ALMA), and is near the sites where construction is underway on the Cherenkov Telescope Array (CTA) and the world's largest instrument, the Extremely Large Telescope (ELT, ESO). With over 340 clear nights annually, the area's exceptional atmospheric stability enables astronomical observations to be made with unparalleled precision. The observatory's unique climatic conditions and extensive instrumentation therefore make it an ideal venue for leading-edge scientific research, especially in the measurement of cosmic distances.

In this highly important field of contemporary astrophysics, Polish scientists have been global leaders for many years. The Araucaria group, established in 2000, devised a groundbreaking method for measuring geometric distances to nearby galaxies using eclipsing binaries. This methodology enabled the determination of the distance to the two nearest galaxies, the Large and Small Magellanic Clouds, with remarkable accuracies of approximately 1% and 2%, respectively. These measurements have enabled the rate of the universe's expansion to be calculated with an accuracy of about 3%. Notably, this finding markedly differs from those obtained from analyses of the microwave background radiation – a discrepancy that poses a significant problem.

Problems with cosmic distances

Trying to reconcile these two independent findings, more than 2,000 scientific papers have been published

MIKOŁAJ KAŁUSZYŃSKI

The 1.5-meter diameter telescope installed at the Polish observatory

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is a Polish astronomer, Professor of physical sciences, and a recipient of the 2021 award of the Foundation for Polish Science (FNP). He is employed at the Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences in Warsaw. The founder and leader of the international Araucaria Project. He has won numerous prestigious Polish and international research grants, including from the European Research Council (ERC), a *Nature* magazine award for outstanding scientific contributions, and the Maria Skłodowska-Curie Science Award in physics. He has also received the Award of the Rector of the University of Warsaw and the Prof. Marian Mięsowicz Award from the Polish Academy of Learning (PAU) for outstanding achievements in physics.

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The Polish astronomical observatory in Chile

to propose modifications to the current cosmological model, which is based on contemporary physics. All these studies have yielded negative results, leading to widespread debate about one of the greatest "crises" in the history of science and the urgent need to look for "new physics." A cornerstone of this pursuit involves measuring the universe's rate of expansion with much greater accuracy. This is also crucial for understanding the physical nature of the enigmatic dark energy, a theoretical construct, and for explaining the accelerated expansion of the universe. Dark energy makes up 68% of the universe, yet our understanding of it remains woefully inadequate, placing us in an uncomfortable position.

For these reasons, the precise measurement of cosmic distances, which helps determine the rate at which the universe is expanding, has once again become a one of the most important challenges in contemporary astrophysics. A number of research teams, including the Araucaria group, have initiated extensive studies to refine and calibrate different methods of measuring cosmic distances. As a result of notable and costly space missions like Gaia, TESS, the James Webb Telescope, and the next generation of giant ground-based telescopes such as the ELT, it has become possible to significantly advance many areas of contemporary astrophysics, including research on the expansion of the universe. However, achieving this requires numerous additional precision measurements using a range of ground-based telescopes strategically located for optimal observation.

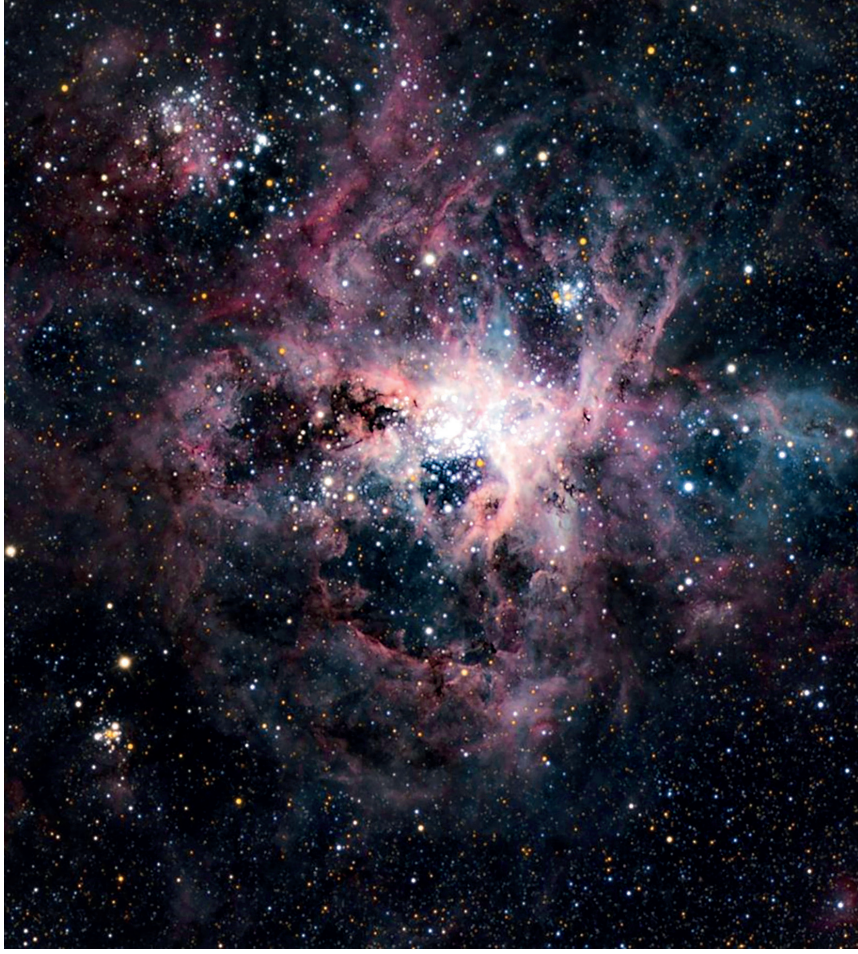
The observatory on Cerro Murphy Hill, established by Prof. Rolf Chini from Ruhr University in Bochum, was ideally suited for this purpose. Initially, the project faced setbacks due to the lack of suitable instruments and the rapidly declining technical condition of the observatory. Nevertheless, early scientific results confirmed the tremendous research potential of this facility, with the contributions of the Polish team becoming particularly significant. Thanks to funding from the Polish Ministry of Education and Science and the dedicated efforts of the Polish team, the observatory was handed over to the Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences in 2020, marking the official establishment of a Polish astronomical observatory in Chile.

The power of multiple telescopes

The funding we received made it possible to revamp the facility into a modern, well-equipped observatory. All residential and technical buildings were renovated, new electrical and fiber optic connections were installed, and tanks for water and diesel fuel were set up with the necessary infrastructure. We also designed and implemented a modern photovoltaic system with a capacity of 35 kWp and an energy storage system of 320 kWh. Thanks to this system and the excellent weather conditions, our observatory is the only one in the world that is fully powered by solar energy. A key component of the project was the construction of three modern optical telescopes with diameters of 0.6, 0.8, and 1.5 meters, manufactured by Astrosysteme Austria (ASA). A dome was also constructed

for the 0.8 m telescope, which was donated by the University of Bochum and optimized for near-infrared observations. Currently, the observatory has tremendous potential for conducting photometric campaigns. Additionally, a high-resolution spectrograph is mounted on the 1.5 m telescope.

This comprehensive suite of instruments enhances our capability to supplement space data, significantly refining the methods of measuring cosmic distances. This unique observatory provides exceptional flexibility in planning and conducting observations, enabling us to undertake very challenging and ambitious projects and maximizing the tremendous synergy between our observations and data collected at other observatories. By the end of 2023, the new telescopes captured their first images of the sky. Despite significant challenges posed by the COVID-19 pandemic and a very complex international situation, this phase in the development of the observatory was completed with great success.



MIROSŁAW KICIA

First light captured by one of the OCM telescopes

Ambitious plans in progress

Thanks to a grant of nearly 14 million EUR received by the Polish team from the European Research Council (ERC) in 2020, plans are underway to construct Poland's largest telescope, which will have a diameter of 2.5 meters. This instrument is slated to be installed in Chile in the latter half of 2025. It will be equipped with an active optics system that will deliver high-quality images and will also include several modern instruments, such as a wide-angle optical camera, an infrared camera, and a super-precise high-resolution spectrograph. This well-equipped telescope will significantly enhance and expand the research capabilities of the observatory.

The observatory's diverse and meticulously planned collection of telescopes and instruments will significantly enhance our understanding of the universe's greatest mysteries, potentially even prompting revisions in contemporary physics. The research conducted at the observatory is expected to make significant contributions to advancing numerous fields within contemporary astrophysics.

It is also important to highlight that the observatory was created through intensive and fruitful international collaboration. It now hosts around 50 astronomers from various countries (predominantly from Germany, France, Chile, Japan, and Austria), including about 30 from Poland. It has evolved into a major international project, conceived, managed, and led by Poles. ■

GRZEGORZ PIETRZYŃSKI

The international research team involved in research at OCM

Further reading:

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