Solaris Project: the search for exoplanets is now on!

Dreaming of a New Earth

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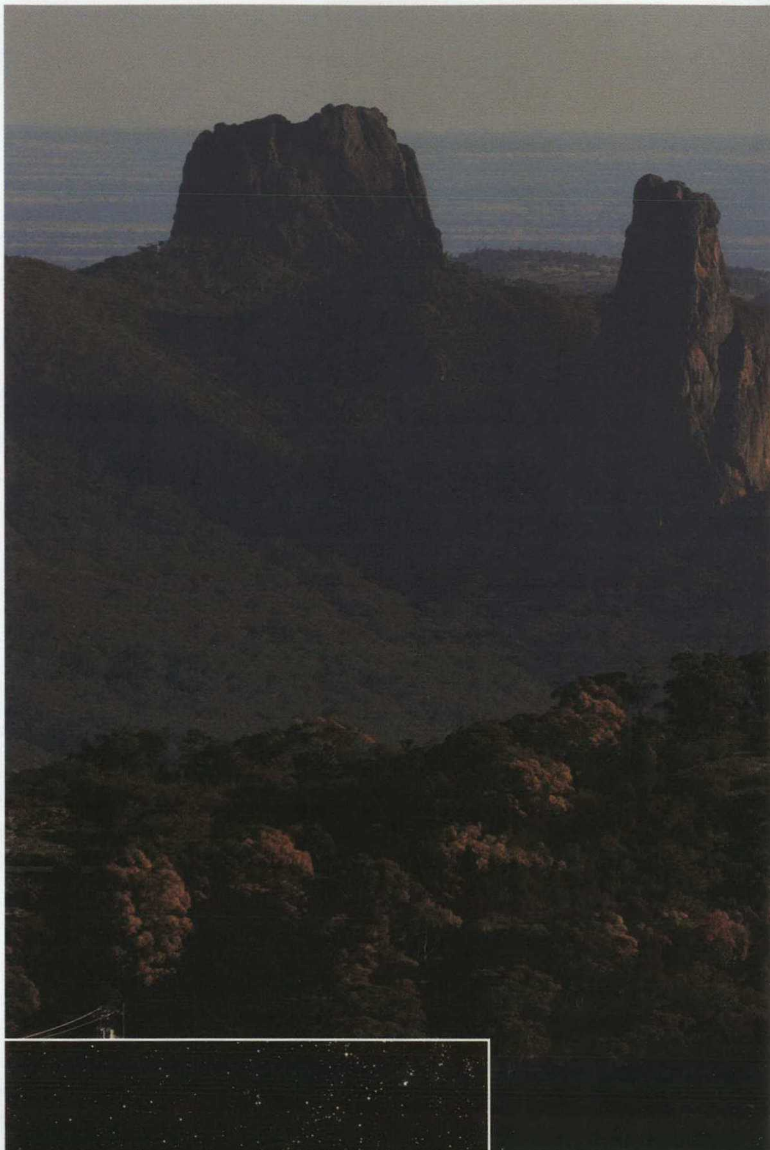


The star-studded night sky has fascinated humankind since the dawn of time. Today, as we grow closer and closer to discovering a new Earthlike planet, our fascination with the skies has not weakened. On the contrary – our enchantment is approaching its zenith

Astronomy has changed dramatically over the centuries. Our current understanding of celestial phenomena has been built on the foundation of many breakthrough discoveries, and expanded over the years. By their very nature, such discoveries have raised more questions than they answered. Today, no one is mystified by falling stars or by the crescent shape of the Moon, and yet we are faced with more questions than ever. Human nature dictates that our desire to find answers is as strong as our need to face challenges. In astronomy, one such challenge is finding another Earth.

Fascinating transits

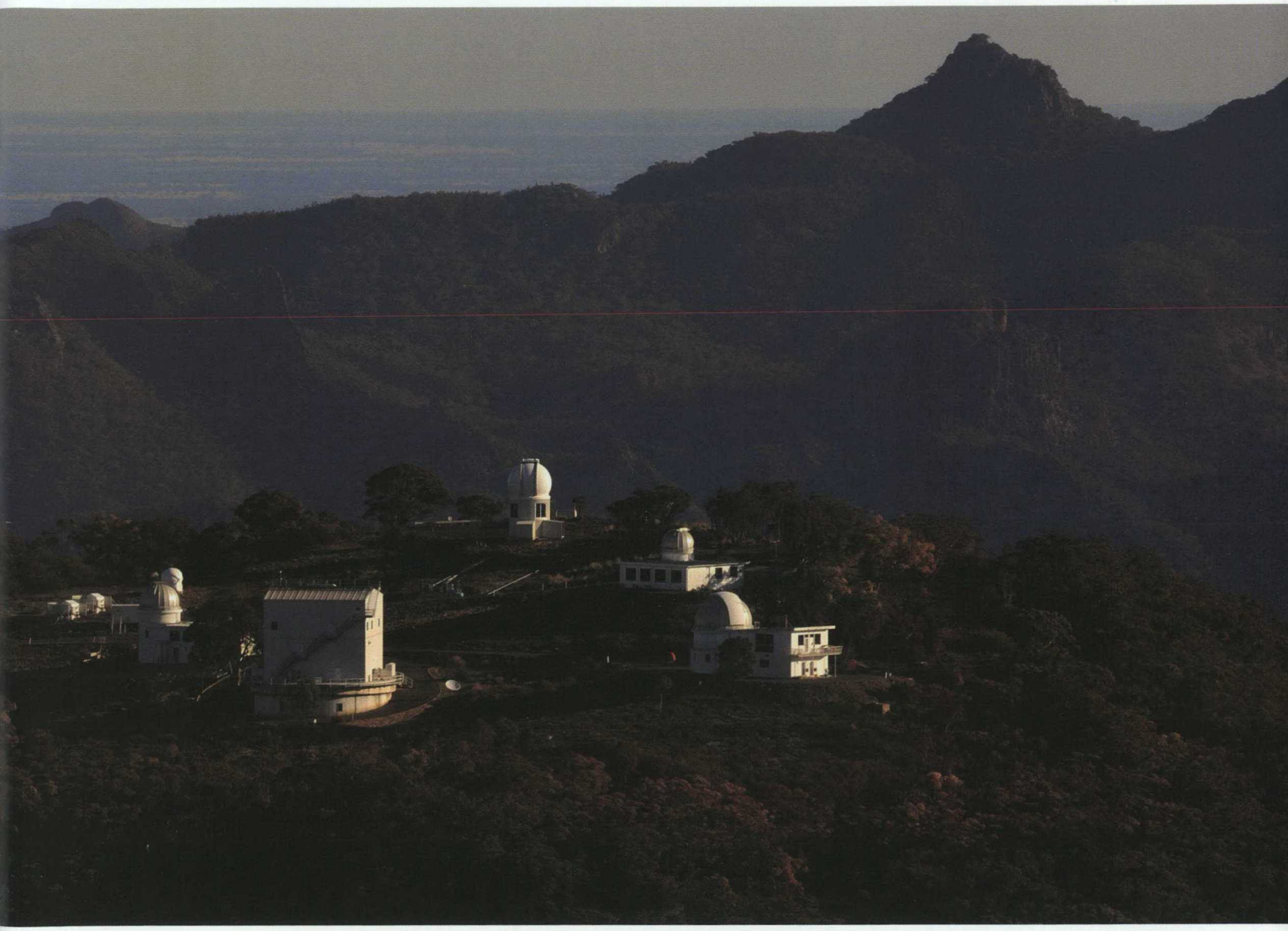
In recent years, the search for exoplanets – i.e. planets oribiting circling a star that is not our own Sun – has risen to the rank of the most popular field of astronomy among amateur astronomers as well as professional researchers. That hardly comes as a surprise; the fascinating issue is unique in its ability to stir imaginations, while each month brings new breakthrough discoveries, with almost a thousand exoplanets having been identified so far. Distant worlds have moved beyond the realm of science fic-

Projekt Solaris

The Tarantula Nebula photographed by one of the telescopes of the Solaris Project

tion, and are now a permanent fixture in the deliberations of some of the greatest minds of our time.

Searching for extrasolar planets is as fascinating as it is demanding. The number of exoplanets that can be observed directly can



be counted on the fingers of one hand, since the light they reflect is extremely weak and gets lost among the light of stars they orbit. As such, most planet detection methods are based on analyzing the light emanating from their host stars.

For example, it is possible to study changes in stellar brightness caused by a planet transiting in front of its parent star's disk. If the planet is close to the star, its diameter is large, and it falls in a certain spatial arrangement, then it may noticeably obscure the star's light.

Another way of detecting distant worlds involves analyzing stellar spectra. A planet orbiting a distant star is subject to its gravity; however, this works both ways, with the star also affected by the planet's gravitational field. This causes the star to move slightly, with the motion resembling a wobble. Analyzing the spectrum of a star swaying in this manner reveals that its spectral lines shift towards the red end of the spectrum when it is moving further away from the Earth and towards violet when it is coming closer. The shifting in spectral lines cor-

The SSO observatory in Australia, home to one of the Solaris telescopes

responds to the value of one of the spatial components of stellar velocity.

These two methods - known as the transit method and the radial velocity or Doppler method, respectively - have been used to discover most of the exoplanets currently known.

Exotic exoworlds

Since the early 1990s, when the Polish scientist Prof. Aleksander Wolszczan discovered the first known extrasolar planets, our understanding of such planets has been evolving quickly. Today we know that distant worlds can be extremely exotic. The first exoplanets found in fact orbit a pulsar - a star formed as a result of a supernova explosion, one of the most energy-generating events that occur in space. However, these planets are not survivors of such a cosmic explosion, but were formed from debris left behind by the exploding star, and as such would certainly not be able to support life.

Other objects which have attracted a great deal of attention from astrophysicists are known as hot Jupiters - planets of relatively large size and low density orbiting close to their host stars, frequently at distances closer than Mercury is to our Sun. The original observations of so many gas giants orbiting stars at close distances have spurred research into the planet formation process. We now know that hot Jupiters are in fact formed at far greater distances from their host stars than their present position, then migrate closer once they are fully formed.

In search of Tatooine

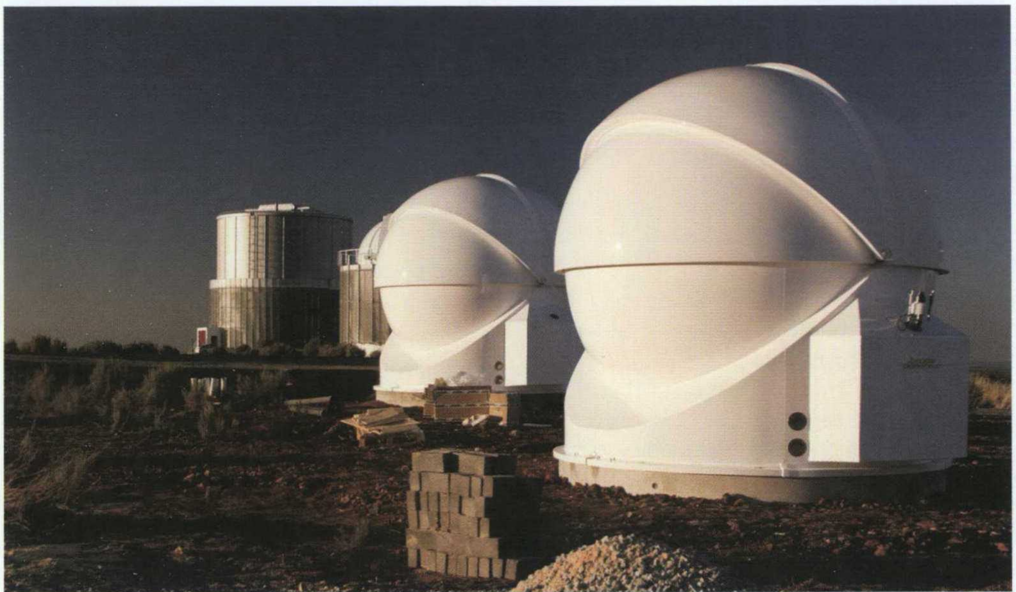
Extrasolar planets also turn out to come in even more varied types. One of the most exotic distant worlds are planets that enjoy sunrises and sunsets of not one, but two suns. These worlds resembling Luke Skywalker's home planet in the "Star Wars" saga - Tatooine - are known as circumbinary planets. They orbit two stars that are bound together gravitationally. Until recently, such worlds were purely the stuff of our imaginations; in recent years, the Kepler space telescope has actually discovered several such systems.

Polish researchers have been making a major contribution to the development of this field. The Solaris project (taking its name from a well-known novel by Polish science fiction author Stanisław Lem, which introduced the concept of a planet orbiting two stars over a decade before George Lucas's film) is the first-ever project dedicated to discovering and studying these extraordinary distant worlds.

Prof. Maciej Konacki's group from the PAS Nicolaus Copernicus Astronomical Centre in Toruń, including Krzysztof Hełminiak, Stanisław Kozłowski, Rafał Pawłaszek, Piotr Sybilski and the present author, is constructing a network of telescopes in the Southern Hemisphere with the specific aim of observing binary star systems which may be orbited by planets. The project uses a timing method to search for these distant, exotic worlds. Dips in the brightness of a stellar system, resulting from its components obscuring one another during orbital motion as a result of the presence of a third body (such as a planet), reach the observer slightly earlier or later than expected. This is due to the shifting position of the center of gravity of the entire system caused by the presence of an additional object, resulting in a periodic variation of the distance between the binary star and the observer, with a period equal to the period of the planet orbiting around the stars. Since the speed of light is finite, the changing brightness of the binary star reaches the observer with a certain irregularity. The Solaris Project searches for extrasolar planets by trying to detect these periodic irregularities.

Solaris telescope network

The task is being implemented through a global network of four fully automated telescopes located at astronomical observatories in Australia (Siding Spring Observatory), Argentina (Complejo Astronómico El Leoncito), and two in South Africa (South African Astronomical Observatory). The Southern Hemisphere was selected for good reasons: the Southern skies feature fascinating objects we cannot observe from Europe, such as the Galactic Center and its neighbor galaxies - the Magellanic Clouds. Additionally, light pollution levels are far lower in the south, and clear nights more numerous. Furthermore, in order to reduce atmospheric effects on optical observations,



Anthony Koeslag

Domes of the Solars-1 and Solaris-2 telescopes (SAAO, South Africa)

The Solaris project is financed by the European Research Council, Poland's Ministry of Science and Higher Education, the Foundation for Polish Science, the National Science Centre, and the PAS Nicolaus Copernicus Astronomical Centre. The total budget exceeds 10 million zlotys.

major observatories are generally built high up in mountains with a dry climate; such conditions are best found on the southern continents. The Polish telescopes of the Solaris project were created next to such major facilities. The longitudinal span between their locations makes it possible to conduct observations around the clock: when night draws to a close at one observatory, the Sun is just setting on another continent.

Each Solaris telescope is equipped with a main mirror a half-meter in diameter on a modified German mount with an extremely precise direct drive. Each telescope is fitted out almost identically with a field derotator, a set of photometric filters, and a state-of-the-art CCD camera. Additionally, each station is coupled to a dedicated computer ensuring its autonomy and, together with the telescope, situated inside a mechanized dome 3.5 meters in diameter. Atmospheric conditions outside the dome are monitored in real time by an extensive sensor system. The operation of the distant observatories is managed from the control center at the PAS Nicolaus Copernicus Astronomical Centre in Toruń.

The main aim of the Solaris Project is to observe over 300 binary star systems in search of circumbinary exoplanets, as well as studying the stars themselves with a hitherto unreached precision. With a global network of telescopes at the project's disposal, and using spectrographs installed on the world's most powerful telescopes, Solaris researchers are able to establish the mass and radius of distant suns with a precision of less than one percent! The Solaris Project is therefore not only offering a chance to discover exotic faraway worlds, but also contributing to the advancement of stellar astrophysics.

However, given that the Solaris telescopes can capture planets around the size of Jupiter, finding another Earth remains an unfulfilled challenge. Given the vast progress made in planetary research in recent years, we can assume that the goal is nevertheless just around the corner, and any questions regarding the discovery of an Earth twin are much more likely to focus on "when" rather than "if." The hope that such a planet will turn out to support life is entirely human - otherwise, after all, the vastness of spacetime would seem to be such a waste. ■

Further reading:

Sybilski P., Kozłowski S. (2011). *Project Solaris - the Southern Hemisphere robotic telescope network,* MNASSA, 70, 131

Solaris Project. Proceedings of the IAU, 282, 7, 111-116.

www.projektsolaris.pl