Wide-eyed Telescope Finds its First Transiting Planets Around Distant Stars

Finding planets that pass in front of their parent stars is so important to understanding how planets form that the European Space Agency will shortly launch the €35M COROT satellite to find them. But a team of UK, French and Swiss astronomers is already paving the way from the ground, with today's announcement of the discovery of two new Jupiter-sized planets around stars in the constellations of Andromeda and Delphinus. They are among the hottest planets yet discovered. Their atmospheres are slowly being whipped away into space by the searing radiation from their parent stars.

These planets are the first to be found during the UK-led SuperWASP (Wide Angle Search for Planets) programme. Using wide-angle camera lenses, backed by top-quality CCD cameras, the SuperWASP team have been repeatedly surveying several million stars over vast swathes of the sky, looking for the tiny dips in the starlight caused when a planet passes in front of its star. This is known as a transit.

Confirmation of the new finds came earlier this month when the team joined forces with the Swiss and French users of SOPHIE, a powerful new French-built instrument at the Observatoire de Haute-Provence. SOPHIE was able to detect a slight wobble in each star's motion as the planets orbited around them. Together the two types of observation confirmed the existence and nature of the planets.

"The partnership between the two instruments is particularly powerful – SuperWASP finds candidate planets and determines their radii, and SOPHIE confirms their nature and weighs them," said Dr. Don Pollacco (Queen's University Belfast), the SuperWASP Project Scientist.

"We're delighted that in its first 4 nights of operation, SOPHIE has detected SuperWASP's first two new planets," said Professor Andrew Collier Cameron (University of St. Andrews), who led the international follow-up campaign.

Approximately 200 planets around other stars are now known, but almost all of them were discovered using large telescopes costing tens of millions of pounds. This requires laborious study of one star at a time, in the hope of finding stars with planets around them.

In contrast, the SuperWASP telescopes look at hundreds of thousands of stars at a time, allowing all those with transiting planet candidates to be identified in one go.

In only a dozen or so of the known systems, has a planet been observed to pass in front of its star. Although the number of known 'transiting exoplanets' is still very small, they hold the key to the formation of planetary systems, and an understanding of the origin of our own Earth. They are the only planets whose sizes and densities can be determined reliably.

The stars around which the new planets are orbiting are both similar to the Sun. One is a little hotter, brighter and bigger, whilst the other is a little cooler, fainter and smaller. The larger star, in the constellation of Andromeda, is over 1,000 light years away. The smaller star, in the constellation of Delphinus, is only about 500 light years distant. Although both stars are too faint to be seen with the naked eye, they are easily detectable with a small telescope.

The planets themselves, known as WASP-1b and WASP-2b, are of a type known as 'hot Jupiters'. They are both giant gas planets, like Jupiter, the largest planet in our solar system, but they are much closer to their parent stars. Whilst Jupiter is nearly 800 million km from the Sun and orbits it once every 12 years, WASP-1b is only 6 million km from its star and orbits once every 2.5 days, WASP-2b is only 4.5 million km from its star and orbits once every 2 days. The very close orbits mean that these planets must be even hotter than the planet Mercury in our solar system, which is nearly 60 million km from the Sun and has a surface temperature of over 400°C. WASP-1b's temperature is estimated to be over 1800C. Both planets show signs that they are losing their atmospheres to space.

The SuperWASP team are currently planning follow-up observations of the two new planetary systems with the Hubble Space Telescope and the Spitzer Space Telescope in order to measure more accurately the sizes and temperatures of the planets, and also to look for indications of any other planets in these systems.

SuperWASP is expected to find dozens more transiting planets over the next few years. A paper detailing these results has been submitted to the journal Monthly Notices of the Royal Astronomical Society.

Background Information

At an international conference today at the Max Planck Institute for Astronomy in Heidelberg, a team of astronomers from the UK, the Canary Islands, France and Switzerland will announce the discovery of two new planets orbiting around other stars. (The conference talk by Dr. Rachel Street is scheduled for 11:50 a.m. local time). The two planets, named WASP-1b and WASP-2b, were identified with the aid of the world's biggest planet-hunting survey telescope, known as SuperWASP, which is located on the island of La Palma. The planetary nature of the discoveries was established using a new instrument, known as SOPHIE, at the Observatoire de Haute-Provence. These two telescopes have just begun joint operations and found the two new planets in their respective inaugural observing seasons.

While no telescope could actually see planets around other stars directly, the passage or transit of the planet across the face of star can block out about 1% of the parent star's light, so the star becomes slightly fainter for a few hours. In our own solar system a similar phenomenon occurred on 8th June 2004, when Venus transited across the Sun's disk.

The SuperWASP telescopes take repeated images of hundreds of thousands of stars in one snapshot, building up a record of how each star's brightness varies with time. By searching through the data for stars which 'wink', candidates for those harbouring planets are identified. These candidate stars are then observed individually to confirm the planet detection, using the famous telescope at Observatoire de Haute-Provence where the first historic exoplanet discovery was made in 1995 by team members Michel Mayor and Didier Queloz.

The SuperWASP planetary transit telescopes

The SuperWASP (Wide Angle Search for Planets) project operates two camera systems – one in La Palma in the Canary Islands and one at Sutherland Observatory, South Africa. These telescopes have a novel optical design comprising eight scientific cameras, each resembling in operation a household digital camera, and collectively attached to a conventional telescope mount. SuperWASP has a field-of-view some 2000 times greater than a conventional astronomical telescope. The instruments run under robotic control and are housed in their own customised building.

The eight individual cameras on each mount are small by telescope standards – the lenses are just 11cm in diameter – but coupled with state-of-the-art detectors and a sophisticated, automated data analysis pipeline, they are capable of producing images of the entire sky, several times per night, and detecting several hundred thousand stars in a single snap-shot.

One nights' observing with SuperWASP generates a vast amount of data, up to 60 GB – about the size of a typical modern computer hard disk (or 100 CD-ROMs). These data are then processed using sophisticated software and stored in a database at the University of Leicester.

By repeatedly observing the same patches of sky, over and over again with the SuperWASP telescopes and measuring accurately the brightness of all the stars detected, the astronomers build up 'light curves' of all the objects to monitor how their brightness varies with time.

For those stars with planets in orbit around them, and in which the orbits are seen almost edge-on, dips in brightness (about 1%) occur when the planet passes in front of the star. In effect, the stars are winking to tell us they have planets. The duration and depth of the dip in the light curve allow the radius of the planet to be measured.

The data from which the two WASP planets were discovered were obtained in 2004, when the northern SuperWASP telescope was operating with just five cameras. Both SuperWASP North and South are now operating robotically with their full complement of eight cameras each. The initial haul of planets discovered promises even greater catches that will place our understanding of these bizarre planets on a secure statistical footing.

The SOPHIE spectrograph

Having detected stars with exoplanet candidates orbiting them, the detections are confirmed using a new instrument – the SOPHIE spectrograph – at the Observatoire de Haute-Provence. The observations reported here were obtained during the first week's operation of this new instrument.

As planets orbit around their host stars, the star itself is tugged around in a small orbit by the pull of the planet. This tiny 'wobble' is detected using the Doppler effect. The spectrum of the star contains many absorption lines produced in the star's atmosphere. These spectral lines occur at characteristic, accurately known wavelengths. However, as the star moves under the influence of the orbiting planet, so the spectral lines shift backwards and forwards in wavelength by tiny amounts.

The SOPHIE spectrograph allows these tiny wavelength shifts to be measured very accurately. In the case of the two planets discovered here, the measured Doppler shifts amount to less than 0.0003 nanometres in wavelength, which corresponds to speeds of less than 200 metres per second.

Similar transits to those observed by SuperWASP could also be produced by low mass stars, so it is essential to measure the Doppler shift in order to 'weigh' the transiting object and distinguish between the two possibilities. The analysis of the Doppler shift allows the planetary nature of the transiting companion to be secured and its true mass to be determined. Combined with the radius determination, it provides the density of the planet, which is crucial information for the study of internal structure of exoplanets.

Acknowledgements

The SuperWASP facility is operated by the WASP consortium, which consists of representatives from the Queen's University Belfast, the University of Cambridge (Wide Field Astronomy Unit), Instituto de Astrofisica de Canarias, the Isaac Newton Group of Telescopes (La Palma), the University of Keele, the University of Leicester, the Open University, the University of St Andrews and the South African Astronomical Observatory.

The SuperWASP North and South instruments were constructed and operated with funds made available from Consortium Universities and the UK Particle Physics and Astronomy Research Council. SuperWASP-North is located in the Spanish Roque de Los Muchachos Observatory on La Palma, Canary Islands which is operated by the Instituto de Astrofisica de Canarias (IAC).

The SOPHIE spectrograph was constructed with funds from INSU (France) and the region 'Provence Alpes Cotes d'Azur' (PACA). Contributions were provided by the Geneva Observatory.

Web links

Pictures of the SuperWASP facility and some of its astronomical images:
http://www.superwasp.org/

The Isaac Newton Group of Telescopes (ING):
http://www.ing.iac.es

The SOPHIE spectrograph at Observatoire de Haute Provence:
http://www.obs-hp.fr/www/guide/sophie/SOPHIE-info.html

The Royal Astronomical Society (RAS):
http://www.ras.org.uk

The Particle Physics and Astronomy Research Council (PPARC):
http://www.pparc.ac.uk

Technical Details

The SuperWASP facility consists of: Solid State Detectors (CCDs) from Andor Technology (Belfast); Canon Optics; Optical Mechanical Inc. Robotic Mount; Customised Enclosure by Jeremy Rainford of Gendall Rainford Products (Cornwall); Liebert Hiross Air-conditioning; GPS Time service by Garmin; Lightning protection equipment by Farrell Engineering (Dublin); Computing by Dell, 3Com and APC. Further technical details can be found at the project home page.
http://www.superwasp.org/technical.htm

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Images

The SuperWASP telescope: http://www.superwasp.org/images/8cams.jpg

Artist's impression of a 'hot Jupiter' during transit:
http://star-www.st-and.ac.uk/~acc4/Transit.jpg