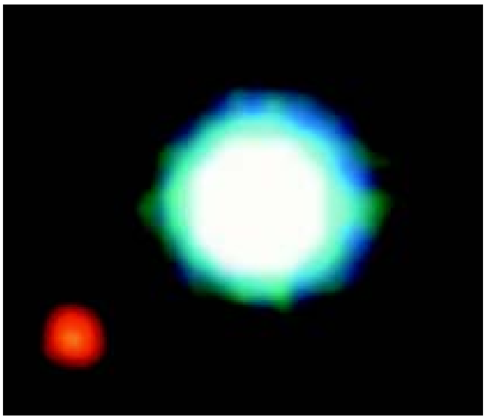


Picture of the Month

Is this the first image of an extrasolar planet? To be sure, ESO's Very Large Telescope has to take a few more such infrared images in the course of the year to see whether the red object is indeed orbiting the main source. This discovery would certainly be a major step in the study of exoplanets (CERN Courier, October 2004, p. 19), even though this star-planet couple does not at all resemble our solar system. The reddish planet would be five times more massive than Jupiter and would orbit the bluish star—a brown dwarf 42 times lighter than the Sun—at a distance exceeding Pluto's orbit. (ESO.)

below (<20 MeV) or much above (>12 TeV) the expectations of most models of non-baryonic dark matter. Fortunately, other less-exotic phenomena occurring in supernovae or black holes are promising alternatives to solve the gamma-ray mystery in the heart of our galaxy.

Further Reading

C. Boehm *et al.*, 2004 Phys. Rev. Lett. **92**, 101301.
J. F. Beacom *et al.*, 2004 www.arxiv.org/abs/astro-ph/0409403.
D. Horns, 2004 www.arxiv.org/abs/astro-ph/0408192.

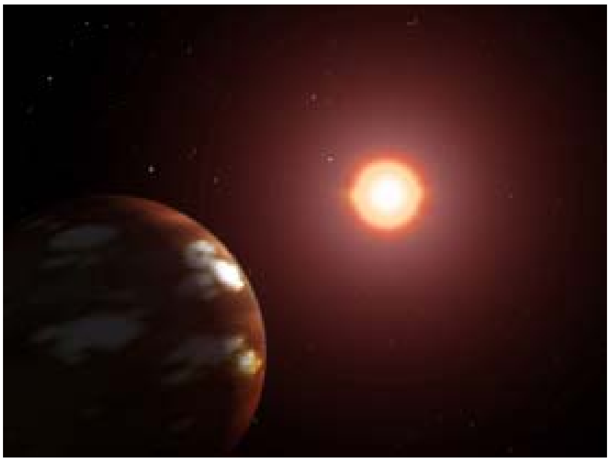
The Hunt for Earth-Sized Exoplanets[2]

Compiled by Marc Türler, INTEGRAL Science Data Centre

The discoveries of three new extrasolar planets were recently announced within the space of a week. With masses around or less than 20 times that of the Earth, these new exoplanets are the lightest known so far. After Jupiter- and Saturn-like extrasolar planets, the detection of these Neptune- and Uranus-sized objects represents an important step in the quest for exoplanets similar to Earth.

Following the discovery in 1995 of the first extrasolar planet, and fuelled by its enormous impact on the general public, the hunt for exoplanets has already led to the discovery of about 130 planets around nearby stars. Two groups on either side of the Atlantic are leading the race. The European group discovered the very first exoplanet around the star 51 Pegasi and was also the first to announce the discovery of a lightweight planet on 25 August this year. The American group, which has discovered about half of all known exoplanets, responded only one week later by announcing their discovery of two Neptune-sized planets.

The presence of a planet orbiting a star is revealed by its gravitational pull making the star wobble around the centre of mass of the system. The wobbling can be detected in a sequence of radial velocity measurements using high-resolution spectra of the star. This method allows the orbit of the planet—in particular, the period and the distance from the star—as well



An artist's rendition of the newly discovered Neptune-sized exoplanet, which orbits the reddish dwarf star Gliese 436 every 2.6 days. (Courtesy NASA.)

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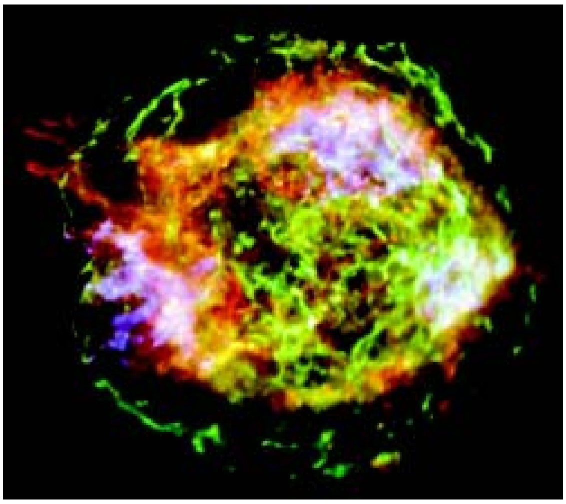

This spectacular X-ray false-colour image of the supernova remnant Cassiopeia A is the most detailed image ever made of the remains of an exploded star. It is the result of a one-million-second (11.5 day) observation by NASA's Chandra X-ray observatory. The point source at the centre of the expanding gas bubble, which is 10 light-years wide, is presumed to be a neutron star created during the supernova explosion some 340 years ago. But, unlike the pulsar in the Crab Nebula, this neutron star does not show evidence for pulsed radiation. (Credit: NASA/CXC/GSFC/U Hwang et al.)

as a lower limit for its mass to be deduced. Statistically, the true mass will in most cases be not much higher than this limit.

The most precise instrument for detecting exoplanets is currently the High Accuracy Radial Velocity Planet Searcher, HARPS. Installed a year ago on the 3.6 m telescope of the European Southern Observatory at La Silla, Chile, it is able to measure the wobbling of stars with a precision of about 1 metre per second, or around walking speed.

The three newly discovered exoplanets are all very close to their star. Discovered with HARPS by the European group (Santos *et al.* 2004), the Uranus-sized planet (14.5 Earth masses) orbiting μ -Arae accomplishes a full revolution of the star in 9.5 days. The two Neptune-sized planets (17 Earth masses) discovered by the American group have even shorter revolution periods of less than three days. One is orbiting a reddish low-mass star called Gliese 436 (Butler *et al.* 2004), while the other orbiting 55 Cancri is the fourth planet found around this metal-rich star (McArthur *et al.* 2004). Astronomers can only speculate on the true nature of these lightweight planets. They are most likely made of a rocky core surrounded by a small gaseous envelope.

The hunt to detect smaller and smaller exoplanets is far from over. HARPS is able to find planets down to a few Earth masses, paving the way for space missions such as COROT, Eddington and Kepler, which aim to detect a possible transit of the planet in front of the star. The next step will be the direct imaging of the planets with projects such as ESA's Darwin interferometric mission or NASA's Terrestrial Planet Finder. Finding the spectral signature of life in the atmosphere of Earth-like planets will be the ultimate goal of these missions.

Further Reading

P. Butler *et al*. 2004 ApJ http://arxiv.org/ abs/astro-ph/0408587.

B. E. McArthur *et al.* 2004 ApJ http://arxiv.org/ abs/astro-ph/0408585.

N. C. Santos *et al.* 2004 A&A http://arxiv.org/abs/astro-ph/0408471.

Laser-Driven Plasma Waves Deliver the Best Beams So Far[3]

Three teams, in the UK, the US and France, have reported breakthroughs in the laser-driven plasma acceleration of electrons. For the first time researchers have been able to create conditions such that the accelerated beam has a low divergence and small spread in energy. This paves the way towards the practical development of compact "table-top" particle accelerators for a variety of applications.

The idea of harnessing the high electric fields generated in laser-driven plasma waves in order to accelerate electrons was first proposed by Toshi Tajima and John Dawson in 1979. The basic principle is to direct an intense laser pulse into a plasma, which sets the plasma electrons oscillating, so creating a relativistic plasma wave in the wake of the pulse. Fields of more than 100 $GeVm^{-1}$—thousands of times greater than achieved with conventional accelerators—can be set up in this way and charged particles can be accelerated as they "surf" the plasma wave. With the advent of high-brightness lasers, this technique of laser wakefield acceleration has in the past decade been

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