Departments

Special Reports

Do Gamma Rays Indicate Galactic Dark Matter?[1]

Compiled by Marc Türler, INTEGRAL Science Data Centre

Is the recent detection of very-high-energy gamma rays from the galactic centre revealing the presence of dark matter? Or, is dark matter at the origin of the electron-positron annihilation in our galaxy? The possibility is not excluded, but it would imply that dark-matter particles are even more exotic than previously thought.

The HESS array of four Cherenkov telescopes (one is shown here) has pinpointed high-energy gamma emission to the galactic centre, and cast doubt on its origin in dark-matter particles. (Courtesy HESS Collaboration.)

It is well known that positrons annihilate with electrons near the centre of our galaxy; the associated emission line at 511keV was detected more than 30 years ago. The spatial extent of the emission as seen by the European Space Agency's INTEGRAL gamma-ray satellite is smooth and corresponds roughly to the bulge of our galaxy. Such a more or less spherical cloud of positrons agrees well with the expected distribution of dark matter in our galaxy, so it has been suggested that light-weight dark-matter annihilation could produce the observed positron population (Boehm *et al.*, 2004).

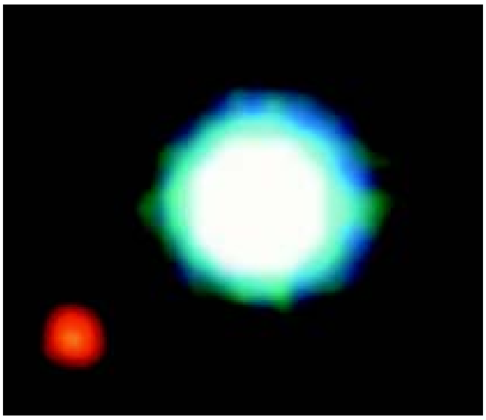
Is it possible, however, that dark-matter particles in the 1-100 MeV range could decay into electron-positron pairs without leaving a detectable signal other than the 511 keV line? This question has indeed been addressed by some researchers, who show that such a decay would inevitably produce gamma rays via an internal "bremsstrahlung" process (Beacom *et al.*, 2004). This emission should have been detected by the high-energy instruments of the Compton Gamma-Ray Observatory, unless the dark-matter particles have masses below about 20 MeV.

Another claim for the possible detection of dark matter has followed the discovery of very-high-energy gamma rays emitted by the galactic centre. The gamma rays, at an energy above 100 GeV, are detected by ground-based telescopes observing the faint Cherenkov light emitted by the electromagnetic shower that results from the interaction of a gamma-ray photon with the terrestrial atmosphere.

The first measurements by the American Whipple telescope and the Australian-Japanese CANGAROO observatory had relatively large uncertainties on the actual position of the gamma-ray source. The results were therefore compatible with a diffuse emission as expected from the annihilation of dark-matter particles. Recent measurements by the European-African High-Energy Stereoscopic System (HESS), a new array of four Cherenkov telescopes in Namibia (CERN Courier, November 2002, p. 7), have shown with a more than 10 times better spatial accuracy that the emission is really bound to the galactic centre.

If dark-matter particles are responsible for these gamma rays observed by HESS, then they must have masses of more than 12 TeV and be very concentrated within a few tens of light-years from the galactic centre (Horns, 2004). Although it cannot be firmly excluded that dark matter is at the origin of the galactic gamma-ray emission observed at 511 keV and/or at TeV energies, this would imply particle masses either much

[1] *The permission for reprinting the present report, as published previously in CERN Courier, Vol. 44, No. 9, November 2004, was granted through Professor Marc Türler and CERN Courier.*



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.

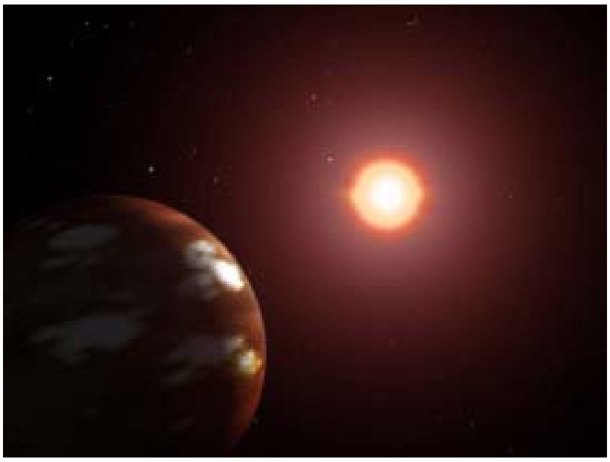
The Hunt for Earth-Sized Exoplanets[2]

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.)

[2] *The permission for reprinting the present report, as published previously in CERN Courier, Vol. 44, No. 8, October 2004, was granted through Professor Marc Türler and CERN Courier.*