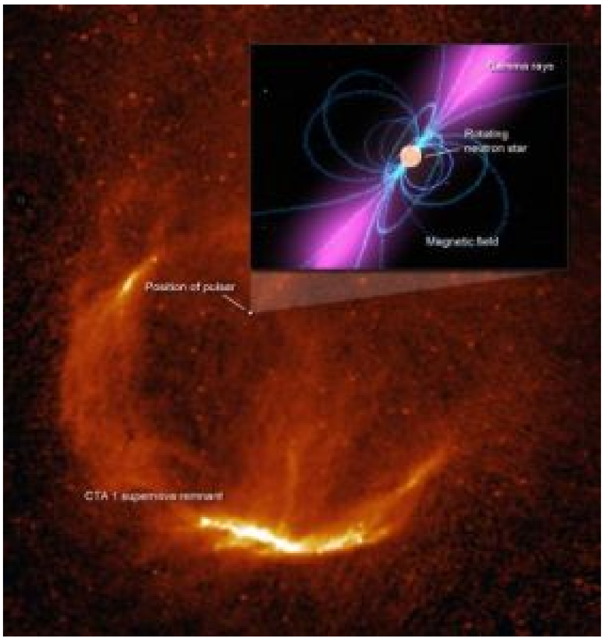
First gamma-ray-only pulsar observation opens new window on stellar evolution

16 October 2008



NASA's Fermi Gamma-ray Space Telescope discovered the first pulsar that beams only in gamma rays. The pulsar (illustrated, inset) lies in the CTA 1 supernova remnant in Cepheus. Credit: NASA/S. Pineault, DRAO

About three times a second, a 10,000-year-old stellar corpse sweeps a beam of gamma-rays toward Earth. This object, known as a pulsar, is the first one known to "blink" only in gamma rays, and was discovered by the Large Area Telescope (LAT) onboard NASA's Fermi Gamma-ray Space Telescope, a collaboration with the U.S. Department of Energy (DOE) and international partners.

"This is the first example of a new class of pulsars that will give us fundamental insights into how stars work," says Stanford University's Peter Michelson, principal investigator for the LAT. The LAT data is processed by the DOE's Stanford Linear Accelerator Center and analyzed by the International LAT Collaboration.

The gamma-ray-only pulsar lies within a supernova remnant known as CTA 1, which is located about 4,600 light-years away in the constellation Cepheus. Its lighthouse-like beam sweeps Earth's way every 316.86 milliseconds and emits 1,000 times the energy of our sun. These results appear in the Oct. 16 edition of *Science Express*.

A pulsar is a rapidly spinning neutron star, the crushed core left behind when a massive sun explodes. Astronomers have cataloged nearly 1,800 pulsars. Although most were found through their pulses at radio wavelengths, some of these objects also beam energy in other forms, including visible light and X-rays.

Unlike previously discovered pulsars, the source in CTA 1 appears to blink only in gamma-ray energies, offering researchers a new way to study the stars in our universe. Scientists think CTA 1 is only the first of a large population of similar objects. "The LAT provides us with a unique probe of the galaxy's pulsar population, revealing objects we would not otherwise even know exist," says Fermi Gamma-ray Space Telescope Project Scientist Steve Ritz, at NASA's Goddard Space Flight Center in Greenbelt, Md.

The pulsar in CTA 1 is not located at the center of the remnant's expanding gaseous shell. Supernova explosions can be asymmetrical, often imparting a "kick" that sends the neutron star careening through space. Based on the remnant's age and the pulsar's distance from its center, astronomers believe the neutron star is moving at about a million miles per hour--a typical speed.

The LAT scans the entire sky every 3 hours and detects photons with energies ranging from 20 million to over 300 billion times the energy of visible light. The instrument sees about one gamma ray each minute from CTA 1. That's enough for scientists to piece together the neutron star's pulsing behavior, its rotation period, and the rate at which it's slowing down.

A pulsar's beams arise because neutron stars possess intense magnetic fields and rotate rapidly. Charged particles stream outward from the star's magnetic poles at nearly the speed of light to create the gamma-ray beams the telescope sees. Because the beams are powered by the neutron star's rotation, they gradually slow the pulsar's spin. In the case of CTA 1, the rotation period is increasing by about one second every 87,000 years.

This measurement is also vital to understanding the dynamics of the pulsar's behavior and can be used to estimate the pulsar's age. From the slowing period, researchers have determined that the pulsar is actually powering all the activity in the nebula where it resides.

"This observation shows the power of the LAT," Michelson says. "It is so sensitive that we can now discover new types of objects just by observing their gamma-ray emissions."

Source: US Department of Energy