Gamma-ray burst mystery is solved

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An international team of scientists using three NASA satellites and a host of ground-based telescopes believes it has solved the greatest remaining mystery of the mysterious gamma-ray bursts (GRBs), the most powerful explosions in the universe. The shorter of two versions of these bursts appear to be caused by the collision of closely orbiting neutron stars or one of those compact stars and a black hole, said Don Lamb, the Louis Block Professor in Astronomy & Astrophysics at the University of Chicago.

"The mystery of short gamma-ray bursts is largely solved," Lamb said. Lamb and his co-authors will describe their finding in a paper that will appear in the Oct. 6 issue of the journal *Nature*.

That paper details the properties of a short GRB that was detected by NASA's High Energy Transient Explorer 2 (HETE-2) satellite on July 9, 2005. A second paper in the same issue of Nature, written by Pennsylvania State University's Derek Fox and his colleagues, will present follow-up observations of the July 9 burst collected by NASA's Chandra X-ray Observatory and Hubble Space Telescope and a variety of ground-based telescopes.

"All the pieces of the puzzle came together for us with this burst," Fox said. "From the HETE detection to the Great Observatories of Chandra and the Hubble Space Telescope, to ground-based observations by our Danish colleagues, we kept on top of this burst from start to finish."

What produces GRBs had baffled scientists for more than three decades after the announcement of their discovery in 1973. GRBs last anywhere from fractions of a second to many minutes. They occur several times a day, come from any direction in the sky, and even their afterglows shine billions of times brighter than their host galaxies.

In 2003, HETE-2 provided solid evidence linking long GRBs to the collapse of massive stars, which signal the births of black holes. Scientists had collected circumstantial evidence supporting that connection for several years. In the case of the short bursts there has been no such buildup of observational evidence, only theoretical calculations and conjectures.

The Nature papers will document several significant findings associated with the July 9 GRB, officially known as GRB 050709:

-- First observation of the optical afterglow of a short burst. Afterglows are produced when the jets emitted by the newly formed black hole slam into the interstellar gas that surrounds it. Scientists need these afterglows to track the bursts to their source.
-- First identification of the galaxy in which a short burst had occurred. "The observation of that optical afterglow led to the identification of the host galaxy," Lamb said.
-- First secure measurement of distance to a short burst. Astronomically speaking, the host galaxy of the July 9 burst has a redshift of 0.16. This translates to a distance of approximately 1 billion light years from Earth, "so it's about 10 times closer than is typical for long GRBs," he said. "That makes short bursts a thousand times less luminous and a thousand times less energetic than long GRBs."
-- First determination of where in the host galaxy the burst occurred. It took place in the outskirts of its host galaxy, meaning that it is a very old object. "This alone is very strong evidence that this burst was due to merging neutron stars," Lamb said.

The burned-out cores of dead stars, neutron stars are extremely compact, measuring no more than 10 miles in diameter. The neutron stars producing a short GRB originally would have formed as massive stars in a more centrally located star-forming region of their galaxy. They would have been binary stars--two stars locked in orbit around each other. But after they exhausted their nuclear fuel and exploded, the force would have kicked them out of the star-forming region into the outskirts of their galaxy.

Long bursts, by contrast, have all taken place in the brightest star-forming region of their host galaxies. That's because long bursts are due to the collapse of massive stars, which have relatively short lifetimes, Lamb said.

Penn State's Fox noted that as a result of the observations, scientists now know that short GRBs are not accompanied by supernovae, the collapse of massive stars. "This was a critical test of the merging neutron stars theory," he said. "Also, we can say that the bursts are beamed, jet-like explosions that illuminate about one-thirtieth of the sky."

The jet-like behavior of the bursts also is important information, Fox said. It tells scientists that any process they use to explain the bursts cannot cause material to blast out in every direction. "It also tells us that the true rate of mergers is 30 times the number of bursts we observe," because they would be invisible unless the jets were pointed along sight lines of Earthbound observers. Although the mystery of the short GRBs has been solved, even more exciting discoveries are in the offing, Lamb said. Merging neutron stars are powerful sources of gravitational waves. Albert Einstein incorporated gravitational waves into his 1916 general theory of relativity. No direct measurement of gravitational waves has ever been made. The relative proximity of short GRBs to Earth means that the gravitational waves they emit could be detected by future experiments.

The search for gravitational waves already is in progress at the Laser Interferometer Gravitational-Wave Observatory (LIGO) in Washington and Lousiana. "The first gravitational wave source that LIGO sees may well be a short gamma-ray burst," Lamb said.

Princeton University's Russell Hulse and Joseph Taylor Jr. earned the 1993 Nobel Prize for the indirect detection of gravitational waves. Scientists eagerly await the next step. "This is the stuff of Nobel dreams," Lamb said.

Source: University of Chicago

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