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Revving up particles in the cosmos

Cygnus X-3 gamma rays may help explain power of quasars

By Ron Cowen

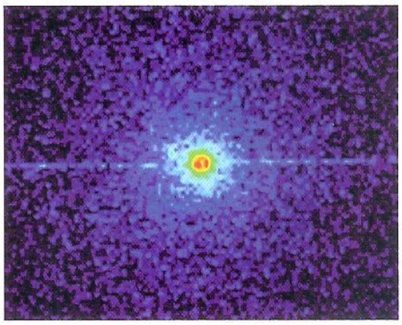
Some 30,000 light-years from Earth, a tiny gravitational monster is tearing material from a companion star, blasting X-rays into space and sporadically hurling out jets of radio-wave–emitting blobs at close to the speed of light.

Two teams have now made the first definitive detection of high-energy gamma rays from this system, a microquasar known as Cygnus X-3. The finding may provide a new window on how this beast — thought to be either a small black hole or a neutron star orbiting an ordinary partner — accelerates charged particles to enormous energies, researchers reported in November at the 2009 Fermi Symposium in Washington, D.C.

Details about the Cygnus X-3 gamma rays may also shed light on how distant quasars pump even greater amounts of energy into space.

Detecting gamma rays from Cygnus X-3 was a feat in itself, made possible by sensitive detectors on two flying observatories. But both teams note that they are most excited about the unexpected clockwork pattern of the gamma-ray emission, which always seems to occur during a lull in high-energy X-rays and just before the onset of powerful radio jets.

The gamma rays, generated by the acceleration of charged particles to extreme energies, may signal "the preparation, the storage of energy for the major radio flares," says Marco Tavani of Italy's Space Astrophysics and Cosmic Physics Institute in Rome. Three times since April 2008, he and his collaborators witnessed the same pattern: "Just one day after the gamma-ray flare — boom! It makes this very major radio flare," Tavani says.



Gamma rays from Cygnus X-3 (shown), a microquasar, offer hints about how it accelerates particles to high energies.

Cygnus X-3 is categorized as a microquasar, and observing it may provide clues to how the more distant quasars, powered by supermassive black holes, accelerate particles to much greater energies. "Microquasars such as Cygnus X-3 are the ideal laboratory for studying the jet phenomena that dominate the most luminous quasars' emissions," comments X-ray astronomer Josh Grindlay of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Because the emissions from microquasars vary on time scales of days to weeks, rather than decades like quasar emissions, systems such as Cygnus X-3 "are the test bed of choice" for probing quasar activity, he says.

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Tavani's team has used the Italian Space Agency's AGILE spacecraft to monitor gamma-ray emissions from Cygnus X-3 for the past two years. The findings have been posted online and are scheduled to appear in an upcoming *Nature*.

Several members of the other team, which observed Cygnus X-3 with the Fermi Gamma-ray Space Telescope, declined to comment on their work before its publication in *Science*. The Fermi team's findings "are completely consistent" with those recorded by AGILE, Tavani says.

The gamma rays observed by AGILE were in the form of flares at energies of about 100 million electron volts. Follow-up radio observations by Tavani's team, along with comparisons with X-ray observations by NASA's Swift satellite, revealed that the flares preceded radio jets and occurred during a decline in high-energy X-rays from Cygnus X-3.

"This is a complete change from previous models," Tavani asserts. Neutron stars and black holes (both thought to power microquasars) can have strong magnetic fields, and Tavani envisions a mechanism in which a magnetic field stores an enormous amount of energy. This energy first accelerates charged particles and prompts them to emit gamma rays. Then the magnetic gate opens, and radio-emitting blobs are pushed out of the system. "The radio jets are the manifestation of what happened before" with the gamma rays, he suggests.

Fermi observations also show that the intensity of the gamma rays varies on a 4.8-hour cycle, known from X-ray observations to be the time it takes for the ultradense member of the Cygnus X-3 system to orbit its partner star. The 4.8-hour signature confirms that the gamma rays come from Cygnus X-3 rather than from another source in the same patch of sky.

"It is an interesting result, but I also think that it's still not clear in detail how the gammas are produced," comments Tod Strohmayer of NASA's Goddard Space Flight Center in Greenbelt, Md. "Nevertheless, it is giving us another tool to study these extremely energetic beasts, and that's exciting."

Both the radio jets and the gamma-ray flares are infrequent, Tavani notes. That could explain why observations in the 1980s of trillion-eV gamma rays in the Cygnus region were never confirmed. It's possible that those detections were of strong but fleeting gamma-ray flares, Grindlay says.

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