Fermi mission finds hints of gamma-ray cycle in an active galaxy

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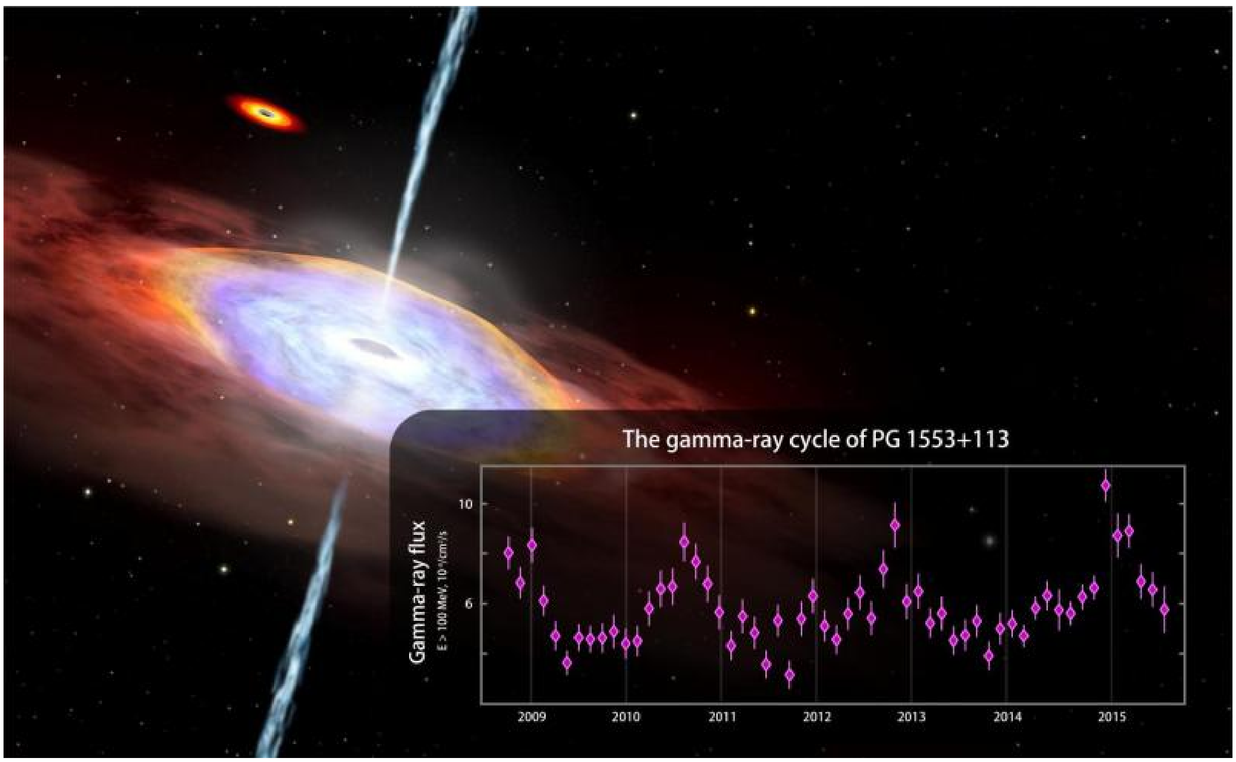

Fermi observations suggest possible years-long cyclic changes in gamma-ray emission from the blazar PG 1553+113. The graph shows Fermi Large Area Telescope data from August 2008 to July 2015 for gamma rays with energies above 100 million electron volts (MeV). For comparison, visible light ranges between 2 and 3 electron volts. Vertical lines on data points are error bars. Background: One possible explanation for the gamma-ray cycle is an oscillation of the jet produced by the gravitational pull of a second massive black hole, seen at top left in this artist's rendering. Credits: NASA's Goddard Space Flight Center/CI Lab

Astronomers using data from NASA's Fermi Gamma-ray Space Telescope have detected hints of periodic changes in the brightness of a so-called "active" galaxy, whose emissions are powered by a supersized black hole. If confirmed, the discovery would mark the first years-long cyclic gamma-ray emission ever detected from any galaxy, which could provide new insights into physical processes near the black hole.

"Looking at many years of data from Fermi's Large Area Telescope (LAT), we picked up indications of a roughly two-year-long variation of gamma rays from a galaxy known as PG 1553+113," said Stefano Ciprini, who coordinates the Fermi team at the Italian Space Agency's Science Data Center (ASDC) in Rome. "This signal is subtle and has been seen over less than four cycles, so while this is tantalizing we need more observations."

Supermassive black holes weighing millions of times the sun's mass lie at the hearts of most large galaxies, including our own Milky Way. In about 1 percent of these galaxies, the monster black hole radiates billions of times as much energy as the sun, emission that can vary unpredictably on timescales ranging from minutes to years. Astronomers refer to these as active galaxies.

More than half of the gamma-ray sources seen by Fermi's LAT are active galaxies called blazars, like PG 1553+113. As matter falls toward its supermassive black hole, some subatomic particles escape at nearly the speed of light along a pair of jets pointed in opposite directions. What makes a blazar so bright is that one of these particle jets happens to be aimed almost directly toward us.

"In essence, we are looking down the throat of the jet, so how it varies in brightness becomes our primary tool for understanding the structure of the jet and the environment near the black hole," said Sara Cutini, an astrophysicist at ASDC.

Motivated by the possibility of regular gamma-ray changes, the researchers examined a decade of multiwavelength data. These included long-term optical observations from Tuorla Observatory in Finland, Lick Observatory in California, and the Catalina Sky Survey near Tucson, Arizona, as well as optical and X-ray data from NASA's Swift spacecraft. The team also studied observations from the Owens Valley Radio Observatory near Bishop, California, which has observed PG 1553+113 every few weeks since 2008 as part of an ongoing blazar monitoring program in support of the Fermi mission.

"The cyclic variations in visible light and radio waves are similar to what we see in high-energy gamma-rays from Fermi," said Stefan Larsson, a researcher at the Royal Institute of Technology in Stockholm and a long-time collaborator with the ASDC team. "The fact that the pattern is so consistent across such a wide range of wavelengths is an indication that the periodicity is real and not just a fluctuation seen in the gamma-ray data."

Ciprini, Cutini, Larsson and their colleagues published the findings in the Nov. 10 edition of The *Astrophysical Journal Letters*. If the gamma-ray cycle of PG 1553+113 is in fact real, they predict it will peak again in 2017 and 2019, well within Fermi's expected operational lifetime.

The scientists identified several scenarios that could drive periodic emission, including different mechanisms that could produce a years-long wobble in the jet of high-energy particles emanating from the black hole. The most exciting scenario involves the presence of a second supermassive black hole closely orbiting the one producing the jet we observe. The gravitational pull of the neighboring black hole would periodically tilt the inner part of its companion's accretion disk, where gas falling toward the black hole accumulates and heats up. The result would be a slow oscillation of the jet much like that of a lawn sprinkler, which could produce the cyclic gamma-ray changes we observe.

PG 1553+113 lies in the direction of the constellation Serpens, and its light takes about 5 billion years to reach Earth.

More information: "Multiwavelength Evidence for Quasi-periodic Modulation in the Gamma-Ray Blazar PG 1553+113," M. Ackermann et al., 2015 November 10, *Astrophysical Journal Letters* iopscience.iop.org/article/10. … /2041-8205/813/2/L41 , *Arxiv*: arxiv.org/abs/1509.02063

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