Astronomer detects a new source of intense gamma radiation

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Artist's impression of the clash of powerful stellar winds. Credit: NASA/C. Reed

Analyzing the data collected by the Fermi Gamma-ray Space Telescope, Maxim Pshirkov of the Sternberg Astronomical Institute discovered a new source confirming that binary systems with strong colliding stellar winds comprise a new population of high-energy gamma-ray sources.His article was published in the latest issue of *Monthly Notices of the Royal Astronomical Society Letters*.

Massive binary star systems composed of hot, luminous Wolf-Rayet stars and massive OB companions generate strong stellar winds. The percussion of these systems may produce fierce photon flux with an energetic potential of more than a hundred mega-electronvolts (MEV), when the distance separating the stars is relatively short. That phenomenon has long been considered a possible source of gamma radiation bursts.

Such radiation has only been detected once at the famous Eta Carinae, which was intensively observed for more than four centuries—after 1834, one of its stars exploded, and for some time, was the most luminous star in the sky. Eta Carinae is comparatively close to Earth—around 7,500 to 8,000 light years away. The stars in this system weigh 120 solar masses and 30 to 80 solar masses respectively, and shine brighter than millions of suns. If they were 10 parsecs (30 light years) away from the Earth, they would be just as luminous as the moon; by contrast, the sun would be invisible at that distance. Seven years ago, high-energy radiation from Eta Carinae was finally detected.

However, a single example was insufficient to confirm the model of binary stars emitting high-energy radiation, and the search for similar sources was continued, which turned out to be a tricky task.

"Recent calculations proved such star types as Eta Carinae to be incredibly rare—probably one per galaxy like the Milky Way, or less," said Maxim Pshirkov. "My colleagues' research resulted in no certain

findings. In 2013, an American-Austrian research team composed a list of seven stellar systems containing Wolf-Rayet stars, where radiation could most probably appear. This research was based on two years of observations and lacked data, so it was only possible to set an upper limit on the HE radiation. I decided to utilize larger set of data: seven years of Fermi-LAT observations. As the result, it was discovered that Gamma Velorum is the source of gamma-radiation at 6.σ. confidence level."

This system contains two stars with masses of 30 and 10 solar masses. Their orbital parameters are well studied and they are separated by about the same distance as Earth and the sun. The luminosity of this binary system is about 200,000 times higher than the sun and strong stellar winds have very high mass loss rate of around 0.00001 and 0.0000002 solar masses every year. Though these figures appear small, actually this is a huge amount of mass, particularly compared to the solar wind, which only amounts to 10^{-14} solar masses per annum. As the stellar winds in the Gamma Velorum system collide on a speed exceeding 1000 kilometers per second, particles are accelerated in the shock. Though the exact mechanism of this acceleration is still unknown, it definitely leads to high-energy photon radiation that was detected by Fermi LAT.

An attentive reader who followed the Higgs boson search at the Large Hadron Collider has probably noticed the standard deviation that Pshirkov mentions, and recalls that in physics, a hypothesis is proved at a statistical accuracy higher than 5σ. That indicates confirmation with a probability higher than 99.999 percent. In other words, Pshirkov's discovery, with its six standard deviations, is quite reliable, though it's still not far from the threshold. According to the article, the researcher had good luck.

"Searching for similar sources in the galactic plane is much more complicated, since it is a powerful gamma-ray source itself, and detecting the small photon excess from colliding stellar winds becomes

much more difficult against this background," says the scientist. "But the Gamma Velorum system lies above the plane surface and it is comparatively close to us. The discovery would probably not have happened if it was further away or closer to the plane."

More information: M. S. Pshirkov. The -LAT view of the colliding wind binaries , *Monthly Notices of the Royal Astronomical Society: Letters* (2016). DOI: 10.1093/mnrasl/slv205

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