The hidden power of the smallest microquasars: Study finds evidence of particle acceleration

January 29 2025, by Renate Hubele

Artist's impression of a microquasar system. A star and a black hole orbit each other closely: mass from the star is captured by the black hole. As a consequence of this, a pair of jets launch away from the black hole. Credit: Science Communication Lab for MPIK/H.E.S.S.

Our home planet is bombarded with particles from outer space all the time. And while we are mostly familiar with the rocky meteorites originating from within our solar system that create fascinating shooting stars in the night sky, it's the smallest particles that help scientists to understand the nature of the universe.

Subatomic particles such as electrons or protons arriving from interstellar space and beyond are one of the fastest particles known in the universe and known as cosmic rays.

The origins and the acceleration mechanisms of the most energetic of these cosmic particles remains one of the biggest mysteries in astrophysics. Fast-moving matter outflows (or "jets") launched from black holes would be an ideal site for particle acceleration, but the details on how and under which conditions acceleration processes can occur are unclear.

The most powerful jets inside our galaxy occur in microquasars: systems composed by a stellar-mass black hole and a "normal" star. The pair orbit each other, and, once they are close enough, the black hole starts to slowly swallow its companion. As a consequence of this, jets are launched from the region close to the black hole.

In the past couple of years there has been growing evidence that microquasar jets are efficient particle accelerators. It is, however, unclear how much they contribute, as a group, to the total amount of cosmic rays in the galaxy. The answer to this question requires understanding if all microquasars are able to accelerate particles or only a lucky few.

Microquasars are usually classified depending on the mass of the star in the system into either "low-mass" or "high-mass" systems, with lower-mass systems being much more abundant.

However, up until now, evidence of particle acceleration was only found for the high-mass systems. For example, the microquasar SS 433, which was recently revealed to be one of the most powerful particle accelerators in the galaxy, contains a star with a mass approximately 10 times that of the sun.

Consequently, it was generally believed that low-mass microquasars were not powerful enough to produce gamma-rays.

Dr. Laura Olivera-Nieto from the Max-Planck-Institut für Kernphysik in Heidelberg, Germany (MPIK) and Dr. Guillem Martí-Devesa from the Università di Trieste, Italy have now made a discovery that shakes this paradigm. The work is published in *The Astrophysical Journal Letters*.

They used 16 years of data from the Large Area Telescope detector onboard NASA's satellite Fermi to reveal a faint gamma-ray signal consistent with the position of GRS 1915+105, a microquasar with a star smaller than the sun. The gamma-ray signal is measured to have energies higher than 10 GeV, indicating that the system could accelerate particles to even higher energies.

The observations favor a scenario in which protons are accelerated in the jets, after which they escape and interact with nearby gas to produce gamma-ray photons. In the paper, they also use data from the Nobeyama 45-meter radio telescope in Japan, which indicates that there is enough gas material around the source for this scenario.

This result shows that even microquasars hosting a low-mass star are capable of particle acceleration. Because this is the most numerous class, this finding has significant implications for the estimated contribution of microquasars as a group to the cosmic ray content of our galaxy.

However, more detections and multi-wavelength studies will be required in order to further narrow down why some systems accelerate particles efficiently, but not all.

More information: Guillem Martí-Devesa et al, Persistent GeV Counterpart to the Microquasar GRS 1915+105, *The Astrophysical Journal Letters* (2025). DOI: 10.3847/2041-8213/ada14f

Provided by Max Planck Society