Astronomers reveal new features of galactic black holes

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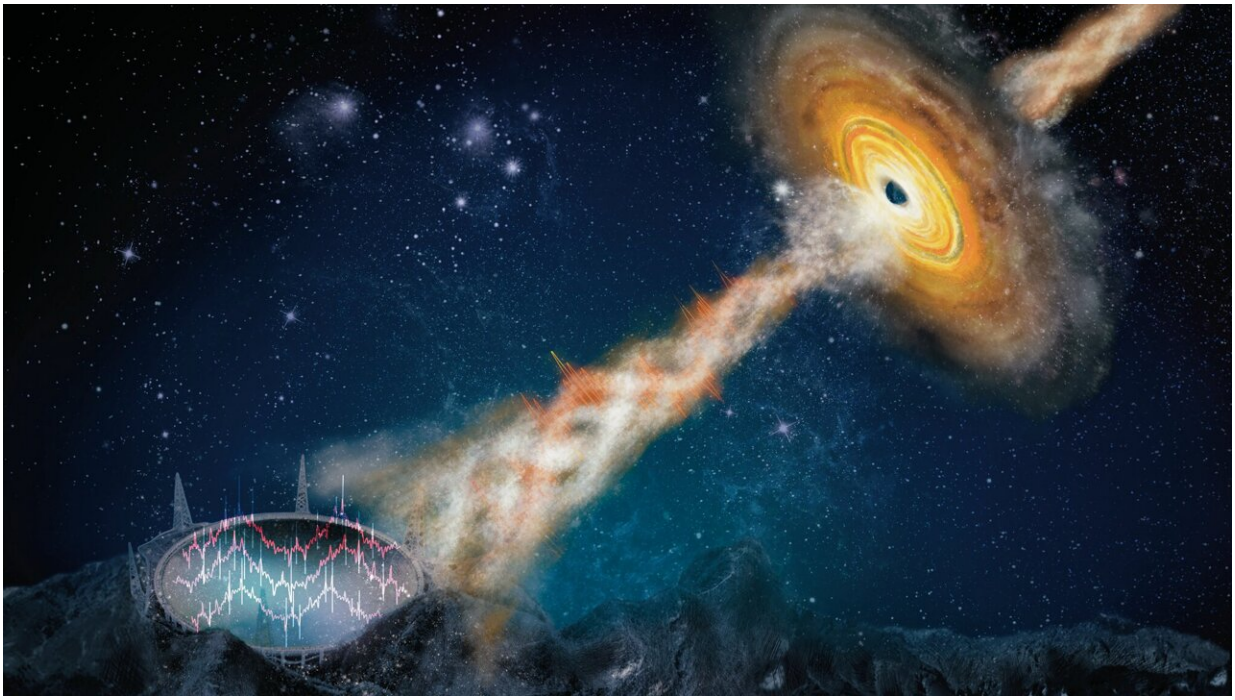

Artist's depiction of microquasar event captured by FAST Telescope. Credit: Professor Wei Wang, Wuhan University

Black holes are the most mysterious objects in the universe, with features that sound like they come straight from a sci-fi movie.

Stellar-mass black holes with masses of roughly 10 suns, for example, reveal their existence by eating materials from their companion stars.

And in some instances, supermassive black holes accumulate at the center of some galaxies to form bright compact regions known as quasars with masses equal to millions to billions of our sun. A subset of accreting stellar-mass black holes that can launch jets of highly magnetized plasma are called microquasars.

An international team of scientists, including UNLV astrophysicist Bing Zhang, reports in *Nature* on a dedicated observational campaign on the galactic microquasar dubbed GRS 1915+105. The team revealed features of a microquasar system that have never before been seen.

Using the massive Five-hundred-meter Aperture Spherical radio Telescope (FAST) in China, astronomers discovered a quasi-periodic oscillation (QPO) signal in the radio band for the first time from any microquasar systems. QPOs are a phenomenon that astronomers use to understand how stellar systems like black holes function. While QPOs have been observed in X-rays from microquasars, their presence outside of this context—as part of the system's radio emission—is unique.

"The peculiar QPO signal has a rough period of 0.2 seconds, or a frequency of about 5 Hertz," said Wei Wang, a professor with China's Wuhan University, who led the team that made the discovery. "Such a signal does not always exist and only shows up under special physical conditions. Our team was lucky enough to catch the signal twice—in January 2021 and June 2022, respectively."

According to UNLV's Zhang, director of the Nevada Center for Astrophysics and one of the study's corresponding authors, this unique feature may provide the first evidence of activity from a "jet" launched by a galactic stellar-mass black hole. Under certain conditions, some black hole binary systems launch a jet—a mix of parallel beams of charged matter and a magnetic field that moves with a swiftness approaching the speed of light.

"In accreting black hole systems, X-rays usually probe the accretion disk around the black hole while radio emission usually probes the jet launched from the disk and the black hole," said Zhang. "The detailed mechanism to induce temporal modulation in a relativistic jet is not identified, but one plausible mechanism would be that the jet is underlying precession, which means the jet direction is regularly pointing towards different directions and returns to the original direction once every about 0.2 seconds."

Zhang said that a misalignment between the spin axis of the black hole and its accretion disk (extremely hot, bright spinning gases surrounding the black hole) could cause this effect, which is a natural consequence of a dragging of spacetime near a rapidly spinning black hole.

"Other possibilities exist, though, and continued observations of this and other galactic microquasar sources will bring more clues to understand these mysterious QPO signals," said Zhang.

More information: Pengfu Tian et al, Subsecond periodic radio oscillations in a microquasar, *Nature* (2023). DOI: 10.1038/s41586-023-06336-6

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