Variable emission from the Milky Way's supermassive black hole

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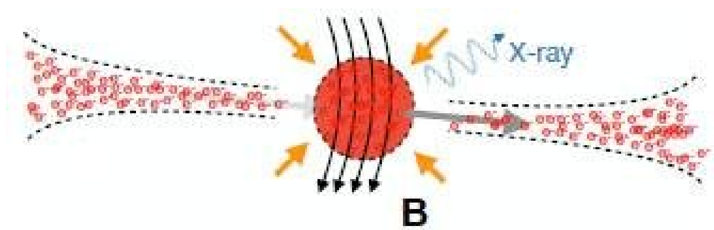

A schematic image of one stage of accretion around the supermassive black hole in the Milky Way's center. Material flows into a spherical region around the black hole with a magnetic field; subsequent compression and expansion of the hot gas produces the infrared and submillimeter emission while scattering produces the X-ray emission. A new paper examines a comprehensive set of multiwavelength, multi-epoch data and presents a relatively simple physical model that can explain most of the variable features. Credit: Harvard-Smithsonian Center for Astrophysics

At the center of our Milky Way lies a supermassive black hole (SMBH) called Sagittarius A* (SgrA*). Supermassive black holes reside at the centers of most galaxies, and when they actively accrete gas and dust onto their surrounding hot disks and environments, they radiate across the electromagnetic spectrum. The mass of SgrA* is about 4 million solar masses, much smaller than the billions of solar-mass SMBHs seen in some galaxies. However, it is relatively close by, only about 25,000 light-years distant, and this proximity provides astronomers with unique opportunities to probe the properties of SMBHs.

Sag A* has been monitored at radio wavelengths since its discovery in the 1950s. Variability was first reported in the radio in 1984, and subsequent infrared, submillimeter, and X-ray observations confirmed variability and found that it often flares. Monitoring programs have concluded that on average Sgr A* is accreting material at a very low rate, only a few hundredths of an Earth mass per year. The fascination with SgrA*'s variability has a practical diagnostic reason, too: Changes in emission are a measure of the dimensions of the region, set by the time for light to travel across it. Flares have been measured that doubled in strength in less than 47 seconds, for example, a time that corresponds to a distance about as small as this black hole's fundamental event horizon size (light cannot escape from within this boundary). These conclusions are in agreement with size inferences made with radio and near infrared interferometry.

CfA astronomers Steve Willner, Giovanni Fazio, Mark Gurwell, Joe Hora, and Howard Smith have been studying the infrared variability of SgrA* with the IRAC camera on Spitzer, combined with simultaneous X-ray and submillimeter variability with Chandra and the Submillimeter Array. They recently teamed with colleagues to analyze and model a comprehensive set of X-ray, near-infrared, and submillimeter observations taken by multiple groups over several decades.

The statistical modeling examines the relative timing of flare events and the frequency and duration of variability at each of the different wavelengths. The astronomers conclude that the variable emission probably arises predominantly from a region about twice the size of the event horizon, and that the same related physical activity is often producing the multiple events seen at different wavelengths. The quantitative models also imply the presence of a dense plasma of electrons along with a modestly strong magnetic field. These conclusions are the first to show that a simple physical model can explain most of the features of Sgr A*'s variability and the correlations between the X-ray, IR, and submillimeter emission, but many puzzles still remain, including the origin of the strongest infrared flares and the reason for the long timescale of variability seen in the submillimeter.

More information: Rapid Variability of Sgr A* across the Electromagnetic Spectrum. arxiv.org/abs/2011.09582
arXiv:2011.09582v2 [astro-ph.HE]

Rapid Variability of Sgr A* across the Electromagnetic Spectrum, G. Witzel, et al, The *Astrophysical Journal Supplement* Series 2021 (in press).

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