Black hole transient GRS 1716−249 investigated in hard and intermediate states

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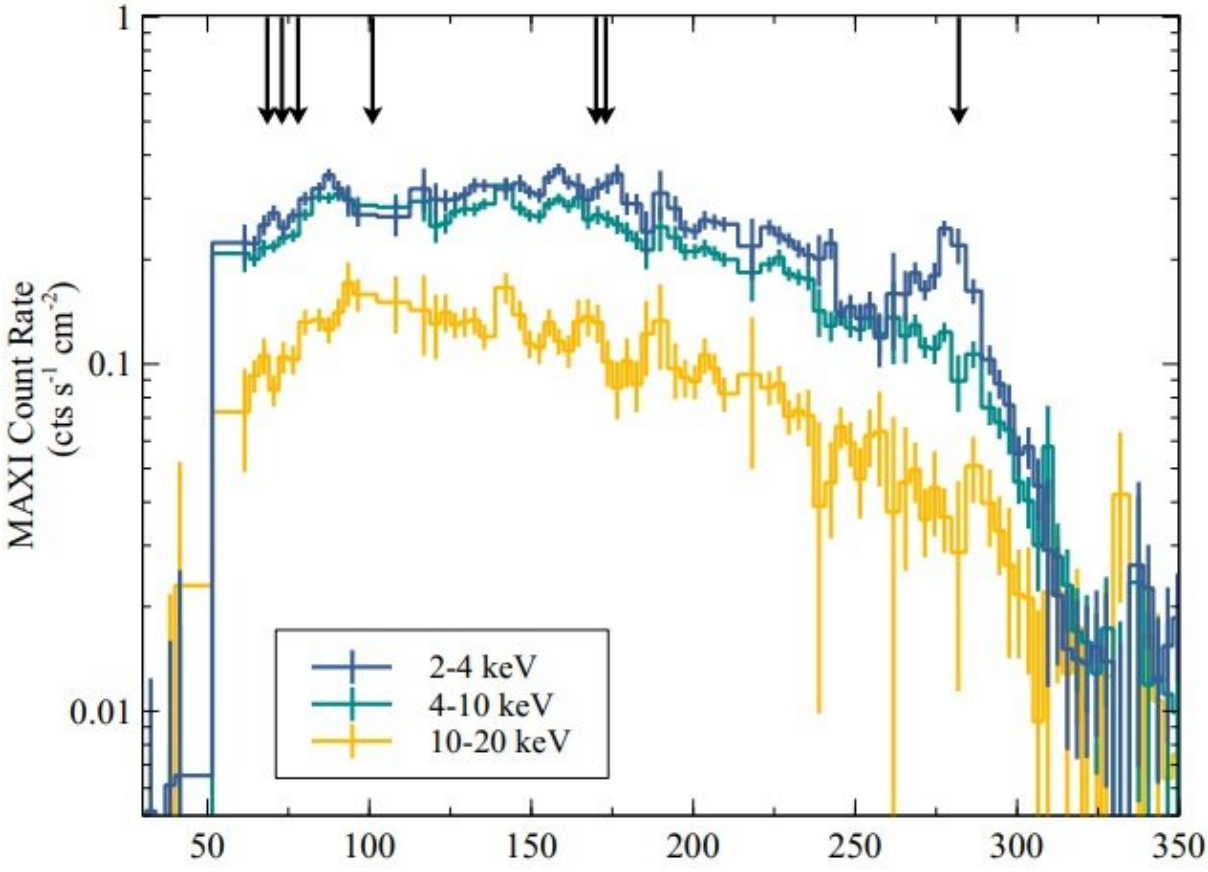

MAXI light curves of GRS 1716−249 in 3-day bin during the outburst in 2016–2017 (blue: 2–4 keV; red: 4–10 keV; yellow: 10–20 keV). The black arrows mark the dates when the NuSTAR observations were taken. Credit: Jiang et al., 2019.

Astronomers have investigated a black hole transient known as GRS 1716−249 with NASA's Nuclear Spectroscopic Telescope Array (NuSTAR). The new study provides crucial insights into properties of the source in its hard and intermediate spectral states. Results of the research were published December 31 on arXiv.org.

X-ray binaries (XRBs) consist of a normal star or a white dwarf transferring mass onto a compact a neutron star or a black hole. Many black hole XRBs show transient events that are characterized by outbursts in the X-ray band.

During these outbursts, astronomers observe mainly the hard and soft spectral states. In the hard state, the spectrum is dominated by a power law-shaped continuum, while in the soft state, the spectrum is dominated by a disc-blackbody emission. However, some black hole XRBs also exhibit an intermediate state in which the hard power-law continuum and a disc thermal emission component make approximately the same contribution to the total spectrum.

Located some 7,800 light years away, GRS 1716−249 is a low-mass X-ray binary (LMXB) discovered in 1993. The source is known to experience outbursts, and one of them, the most recent, was detected in December, 2016. Astronomers found that during this outburst, GRS 1716−249 approached the soft state three times; however, it never reached the canonical soft state.

In order to shed more light on the spectral states of GRS 1716−249, a team of astronomers led by Jiachen Jiang of Tsinghua University in Beijing, China, has analyzed seven NuSTAR observations of this source.

"In this paper, we conduct detailed spectral analysis of the seven NuSTAR (Harrison et al. 2013) observations of GRS 1716−249 triggered during the outburst in 2016–2017," the astronomers wrote in

the paper.

The latest outburst of GRS 1716−249 lasted eight months until it returned to the quiescent state. The first six NuSTAR observations unveiled in a canonical hard state, while the last observation disclosed its intermediate state as both a disc thermal component and a power-law continuum were identified.

In particular, the astronomers explained that the first four observations were taken at the rising phase of the outburst. In this phase, the spectra of GRS 1716−249 showcase a consistent spectral shape but an increasing X-ray luminosity, from 0.8 to 1.2 percent of the Eddington luminosity.

Afterward, the spectra of the next two observations become softer although the source remains at a similar X-ray luminosity. It was noted that the the sixth observations shows the lowest high energy cut-off in the coronal emission, what indicates a cool coronal temperature (below 50 keV).

Finally, the spectra of the seventh observation exhibit a combination of a disc thermal emission, a softer coronal emission, and a strong disc reflection component. This, according to the astronomers, indicates that GRS 1716−249 is in a very low flux intermediate state. It was also found that the source shows the lowest X-ray luminosity in the last observation, but has a similar absolute flux from the disc reflection component when compared to previous observations, what suggests a possible change in the geometry of the corona.

In concluding remarks, the researchers noted that the intermediate state of GRS 1716−249 shows a similar disc density as the intermediate state of the X-ray source Cygnus X-1, but has a much lower luminosity in the X-ray band.

More information: A NuSTAR View of GRS 1716−249 in the Hard and Intermediate States, arXiv:1912.13215 [astro-ph.HE] arxiv.org/abs/1912.13215