Research investigates a high-frequency bump in the X-ray binary GX 339-4

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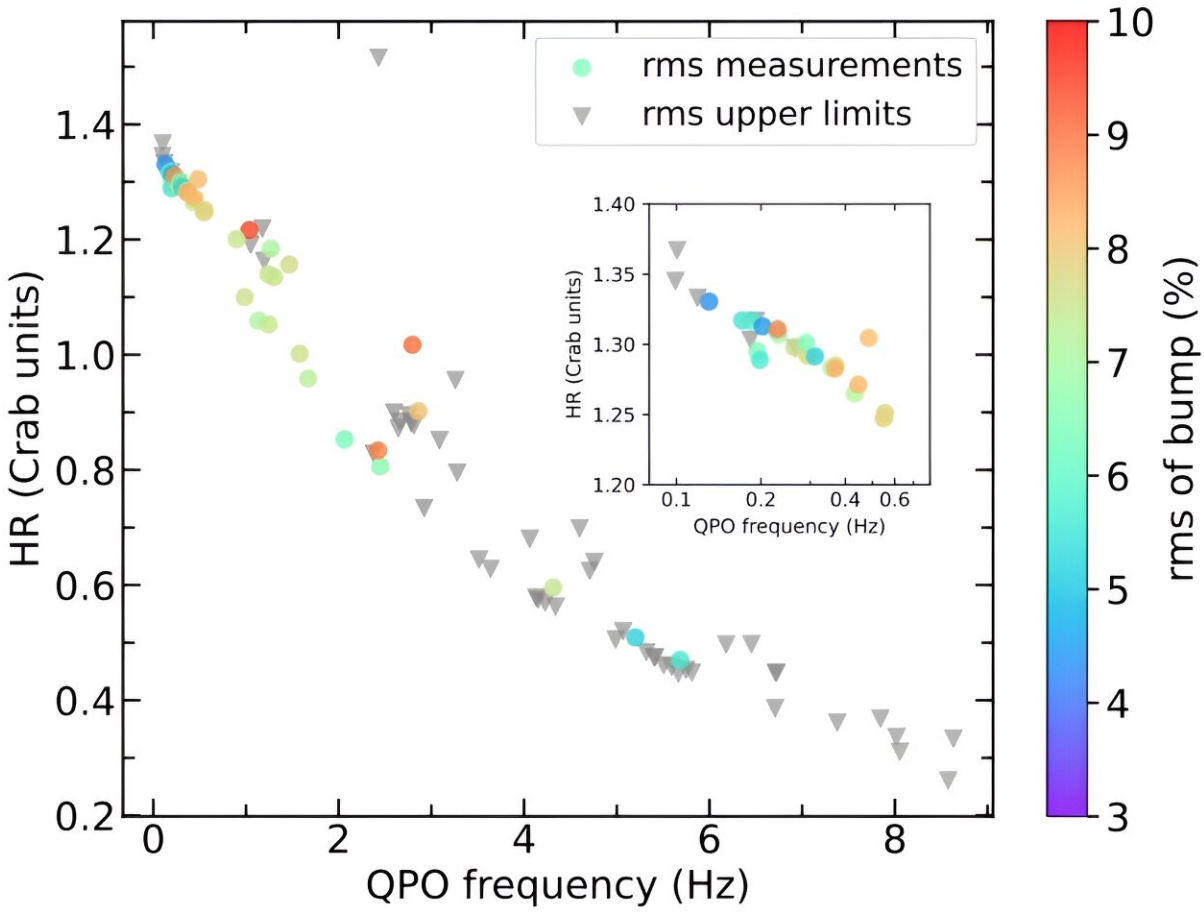

Hardness ratio versus type-C QPO frequency plot for the 91 observations of GX 339–4. The color of the points indicate the rms amplitude of the bump. The colored circles indicate the significant measurements, while the gray triangles are upper limits. Credit: *arXiv* (2023). DOI: 10.48550/arxiv.2311.12661

An international team of astronomers has inspected a low-mass X-ray binary system known as GX 339-4. Results of the study, reported in a paper published Nov. 21 on the pre-print server *arXiv*, shed more light on the high-frequency bump observed in the power density spectrum of GX 339–4 and provide more insights into the properties of this system.

X-ray binaries (XRBs) are systems composed of a normal star or a white dwarf transferring mass onto a compact object, which may be either a neutron star or a black hole. XRBs are further divided into low-mass X-ray binaries (LMXBs) and high-mass X-ray binaries (HMXBs), depending on the mass of the accompanying star.

At a distance of about 39,000 light years away from the Earth, GX 339-4 is a recurrent black hole LMXB first detected in 1973. Its black hole is estimated to be at least 5.8 times as massive as the sun. GX 339–4 has undergone frequent outbursts, experienced quasi-periodic oscillations (QPOs) and displayed all the black hole accretion states during the last 30 years.

All in all, GX 339-4 has been comprehensively investigated at all wavelengths, which makes it one of the most studied black hole LMXBs. Previous observations of this system have found a high-frequency bump in its power density spectrum (PDS) that should originate in the X-ray corona. This bump is characterized by a frequency exceeding 30 Hz and has a root mean square (rms) of around 2–3%.

A group of astronomers led by Yuexin Zhang of the University of Groningen, The Netherlands, decided to analyze archival data from the Rossi X-ray Timing Explorer (RXTE), spanning from 1996 to 2012, to explore the nature of this high-frequency bump.

As a result, the team detected the bump in 39 RXTE observations of GX 339-4, all of which also show type-C QPOs in the low-hard state and the

hard-intermediate state. They found that the rms of the bump depends on the frequency of the type-C QPO and the hardness ratio (HR).

"When the HR is between ~0.8 and 1.3 and the QPO frequency is between ~0.1 Hz and 2 Hz, the rms amplitude of the bump is ~4–9%, whereas when the HR decreases below 0.8 down to 0.2 and the QPO frequency increases from ~2 Hz up to 8 Hz the bump is not detected with upper limits of the rms amplitude between 3 and 10%," the researchers explained.

In general, the astronomers found that the radio flux of GX 339–4 is quite low when compared to similar X-ray binaries, but the rms amplitude of the bump is high and the X-ray corona is hot. This indicates that in GX 339–4, more energy in the system in the low-hard and hard-intermediate states is directed towards the X-ray corona than in the case of other investigated black hole LMXBs.

According to the authors of the paper, the presence of the bump in GX 339–4 suggests that in the hard state of this source, most of the accretion energy is directed to the corona instead of being used to eject the radio jet.

More information: Yuexin Zhang et al, A systematic study of the high-frequency bump in the black-hole low-mass X-ray binary GX 339-4, *arXiv* (2023). DOI: 10.48550/arxiv.2311.12661