Ultra-luminous X-ray pulsar Swift J0243.6+6124 investigated with AstroSat

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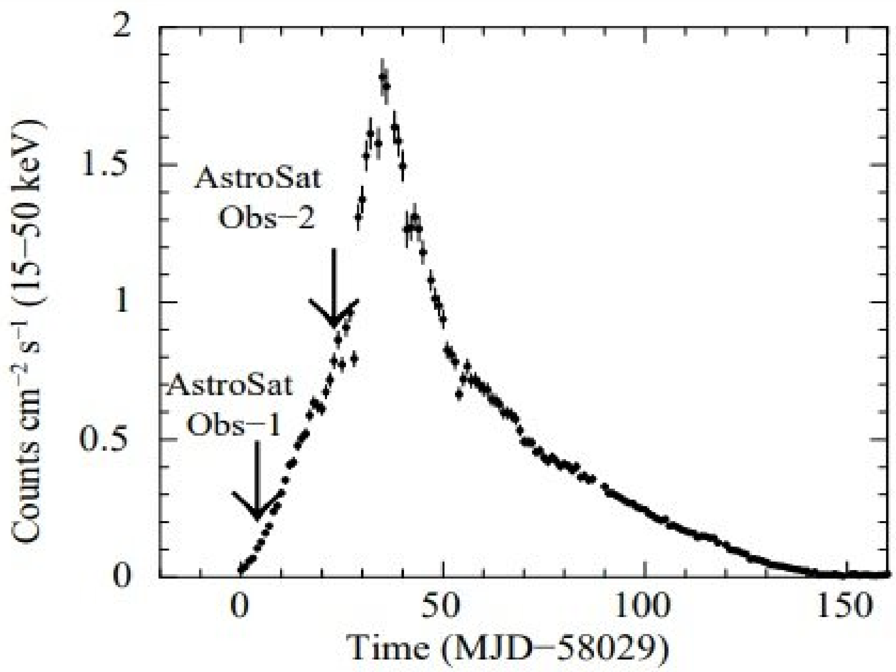

Swift–BAT light curve of J0243 in the 15-50 keV range, from October 3, 2017 (MJD 58029) to February 11, 2018 (MJD 58160). Arrows mark times of AstroSat observations, the first starting on MJD 58033.193, the second on MJD 58052.619. Credit: Beri et al., 2020.

Using India's AstroSat spacecraft, astronomers have performed broadband timing and spectral observations of an ultra-luminous X-ray (ULX) pulsar known as Swift J0243.6+6124. Results of this observational campaign, presented in a paper published October 16 on arXiv.org, reveal more details about the properties of this pulsar.

ULXs are point sources in the sky that are so bright in X-rays that each emits more radiation than a million suns emit at all wavelengths. They are less luminous than active galactic nuclei, but more consistently luminous than any known stellar process. Although numerous studies of ULXs have been conducted, the basic nature of these sources still remains unknown.

Some ULXs exhibit coherent X-ray pulsations, and therefore are classified as ULX pulsars (ULPs). To date, only a handful of ULPs have been identified and one of them is Swift J0243.6+6124 (or J0243 for short). The discovery of this pulsar was reported in October 2017, when X-ray pulsations of approximately 9.86 seconds were detected from a transient X-ray source in outburst by NASA's Swift spacecraft in the 0.2-10 keV band. At a distance of about 23,000 light years, J0243 is the first galactic ULP detected so far.

J0243 was further observed with AstroSat during its 2017-2018 bursting activity, as part of a multi-wavelength campaign. Now, a team of astronomers led by Aru Beri of the Indian Institute of Science Education and Research (IISER) in Mohali, India, has published results of these observations, which could help us better understand the nature of this pulsar.

"AstroSat observed J0243 twice during its 2017-18 outburst, and we have analyzed data obtained over a broad energy range (0.3-150 keV) with all three of its X-ray instruments," the researchers wrote in the paper.

AstroSat allowed Beri's team to detect X-ray pulsations up to 150 keV during the second observation. However, for the relatively fainter first observation, pulsations were detected only up to 80 keV. The average pulse profiles revealed a double-peaked behavior during both observations, separated by approximately 19 days, which could be due to the contribution from both magnetic poles of the neutron star or two sides of a fan beam from one pole.

The results indicate that J0243 was accreting at sub-Eddington level (about 70 undecillion erg/s) during the first AstroSat observation and at super-Eddington level (about 600 undecillion erg/s) when it was observed for the second time. The astronomers noted that spectral data at the sub-Eddington level could be modeled well using an absorbed high-energy cut-off power law and a blackbody. When it comes to the super-Eddington phase, they added that it requires additional components such as another blackbody and a Gaussian component for the iron emission line.

The authors of the paper assume the presence of two blackbodies: one with a radius of about 18−19 km for the high temperature one, and another with a radius of 121−142 km for the low temperature one. This possibly indicates contribution to thermal emission from the accretion column and optically thick outflows.

More information: Beri et al., AstroSat Observations of the first Galactic ULX Pulsar Swift J0243.6+6124, arXiv:2010.08334 [astro-ph.HE] arxiv.org/abs/2010.08334