New observations shed more light on the nature of a millisecond pulsar binary

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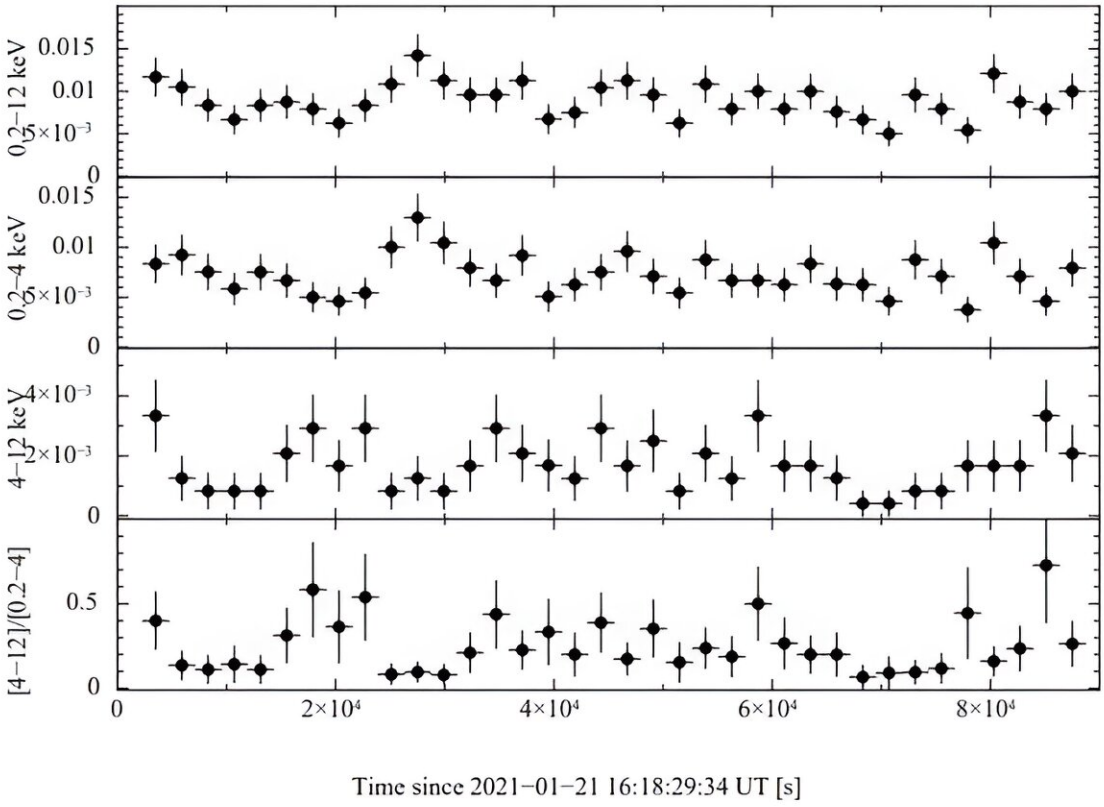

XMM-Newton's EPIC-pn light curve of J1431 in the 0.2-12 keV, 0.2-4 keV, 4-12 keV ranges and the hardness ratio between the hard and soft bands, displayed with a bin size of 2,400 s. Credit: De Martino et al., 2024.

Using ESA's XMM-Newton satellite, European astronomers have performed X-ray observations of a millisecond pulsar binary known as PSR J1431−4715. Results of the observational campaign, published September 3 on the pre-print server *arXiv*, provide more insights into the nature of this system.

Pulsars are highly magnetized, rotating neutron stars emitting a beam of electromagnetic radiation. The most rapidly rotating ones, with rotation periods below 30 milliseconds, are known as millisecond pulsars (MSPs). Researchers assume that they are formed in binary systems when the initially more massive component turns into a neutron star that is then spun up due to accretion of matter from the secondary star.

A class of extreme binary pulsars with semi-degenerate companion stars is dubbed "spider pulsars." These objects are further categorized as "black widows" if the companion has extremely low mass (less than 0.1 solar masses), while they are called "redbacks" if the secondary star is heavier.

PSR J1431−4715, or J1431 for short, is an MSP binary located most likely between 5,250 and 8,400 light years away from the Earth. With a spin period of 2.01 milliseconds and spin-down power at a level of 68 decillion erg/s, it is one of the fastest and most energetic pulsars.

Previous observations have found that J1431 pulsed radio emission is affected by strong eclipses at the binary orbital period of about 10.8 hours. It was also found that the system hosts a non-degenerate donor star with a minimum mass of 0.12 solar masses and therefore J1431 was classified as a redback.

However, given that J1431 was discovered in 2015, it remains a poorly studied MSP. That is why a team of astronomers led by Domitilla de Martino of the Astronomical Observatory of Capodimonte in Naples,

Italy, decided to investigate J1431 in X-rays using XMM-Newton. Their study was complemented by optical multi-band photometric data from the European southern Observatory's 3.5m New Technology Telescope (NTT) in Chile.

The observations found that the X-ray spectrum of J1431 is featureless and consistent with non-thermal emission with a power law photon index of 1.6 and negligible absorption. Moreover, the presence of a thermal component was detected, which may point to the contribution of the heated polar cap in the soft X-rays.

The collected data indicate that the companion star is an early F-type star with a mass of around 0.2 solar masses, which confirms the redback nature of J1431. However, the companion star turned out to be hotter than in the majority of redbacks as its dayside and nightside temperatures were measured to be about 7,500 and 7,400 K, respectively.

Based on the observations, the astronomers found that J1431 has a binary inclination of 59 degrees and that the system is located approximately 10,100 light years away, therefore farther than previously estimated. The obtained data also suggest that the pulsar is massive as its mass is assumed to be within the range of 1.8–2.2 solar masses.

More information: D. de Martino et al, X-ray and optical observations of the millisecond pulsar binary PSRJ1431-4715, *arXiv* (2024). DOI: 10.48550/arxiv.2409.02075

millisecond-pulsar-binary.html