# What’s cooking in the ‘LMC X-4’ binary star system?

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In a new study, researchers from the Raman Research Institute (RRI), Bengaluru, present observations about the binary star system ‘LMC X-4' in the neighbouring Large Magellanic Cloud satellite galaxy. Their findings, published in the *New Astronomy Journal*, uses data from receivers aboard spacecraft XMM-Newton launched by the European Space Agency, and the Rossi X-ray Timing Explorer satellite from NASA. The findings hold important clues in the mechanics behind X-ray emissions seen from this binary system of stars.

The Large Magellanic Cloud (LMC) is a satellite galaxy that orbits our own, much larger, Milky Way. LMC X-4 is a two-star system consisting of a pulsar - a highly magnetised neutron star beaming X-rays - and a companion star. Scientists believe that such pulsars are formed after a supernova explosion, when a dying star spectacularly shoots material and expanding shockwaves into space, before being reborn as a compact star. The neutron stars are so dense that their mass could be twice that of the Sun, with a radius of only 10 kilometres. Its high density makes its magnetic field a trillion times stronger than Earth’s.

In this study, Dr. Aru Beri and Dr. Biswajit Paul from RRI examined characteristics of the X-ray signals emitted from LMC X-4, using signal processing techniques and analysis. The scientists observed three states in the intensity of X-ray emitted by the pulsar: ‘flaring’, ‘persistent emission’, and ‘eclipse’.

Neutron stars evolve through ‘accretion’ - the continuous addition of usually gaseous particles by gravitational attraction. Due to very strong gravitational attraction, the neutron stars accumulate gas in streams from its orbiting companion onto ‘hotspots’ on the surface of the neutron star, which briefly flare with X-rays when the accretion abruptly increases. The ‘flaring state’ of LMC X-4, which happens when there is a sudden increase in the amount of material accreting onto the surface of the neutron star resulting in larger X-ray radiation, showed four distinct flares. These flares exhibit a pattern of pulsation that, when plotted, is broad and sinusoidal in shape. This is followed by a non-flaring or ‘persistent emission state’ where a low signal of X-rays is recorded. The third state of ‘eclipse’ is identified by an absence of X-rays when our view of the neutron star is blocked by its much larger companion.

The researchers focused on the complex structure of the X-ray pulses during the persistent emission state, defined as the region with no flares and no eclipse. They observed ‘dips’ in the pulses during the period of steady, low X-rays, identified by sharp drops in the intensity of radiation. They attribute this to the hotspots becoming obscured by optically dense bands of accreting gas that falls from the companion star into the neutron pulsar star.

The study estimates the timescales involved in the formation of the flares, and the subsequent formation of the accretion column that causes dips, stating that “observed differences in the pulse profiles during and after the flares suggest that significant change in the accretion stream happens during the transition between flares and the persistent state”.

This study takes us a step closer to confirming theories on the nature of light, magnetism, gravity and general relativity. Observing and analysing cosmic phenomena such as pulsars, enables a deeper understanding of some extreme conditions in the cosmos that cannot be created in laboratories. This study gives insight into the behaviour of plasma in extremely high magnetic field and very strong gravity.

*The researchers of the study have plans to further their research on X-rays emitted from other stars. “We are currently making an X-ray polarimeter named POLIX, which is the main scientific instrument onboard XPoSat, a satellite mission of ISRO to be launched in 2019, dedicated for investigation of polarisation properties of cosmic X-ray sources”, shares Dr. Paul, about his future plans. Observations with POLIX will allow scientists to determine the magnetic field structure of neutron stars, the key element in the formation of the flares and dips in LMC X-4 that have been discovered with the current investigation.*