The origin of super-Eddington Flares in the high-mass X-ray binary LMC X-4

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Abstract

LMC X-4 is a bright X-ray pulsar in a massive binary system that shows irregular super-Eddington flares. The flares have a typical duration of several kiloseconds, often occur in series, and are accompanied by changes in the pulse profile and X-ray spectrum. The nature of these flares remains unknown and may arise from various mechanisms related to the interaction of the material surrounding the neutron star with its magnetosphere, or from rearrangements of its internal structure. In this work, we performed deep analysis of the X-ray flux during observations that contain flaring activity. We focused on two main things: the rotation dynamics of the neutron star and the changes in its pulse profile shape during the flares. Our analysis shows that while the outbursts do not cause significant shifts in the pulse period, the period derivative ($$) exhibits noticeable changes after the flares. Furthermore, during all observations, the absolute value of $$ was an order of magnitude higher than the long-term trend. We also found that the pulse profile changes during outbursts depend strictly on luminosity. This fact rules out theories that predict new hot spots on the neutron star surface or energy release far from it. Instead, the changes are likely caused by variations in the accretion rate within a stable accretion column. Moreover, we detected a wide variety of distinct pulse profiles that show no correlation with the superorbital period. The best mechanism to explain these outbursts is an instability at the inner edge of the disk, where the magnetic field disrupts the accretion disk near the corotation radius.

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