Observation and appearance of magnetospheric instability in flaring activity at the onset of X-ray outbursts in A 0535+26

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We study the spectral and temporal behavior of the High Mass X-ray Binary A 0535+26 during a 'pre-outburst flare' which took place ∼5 days before the peak of a normal (type I) outburst in August/September 2005. We compare the studied behavior with that observed during the outburst. We analyse RXTE observations that monitored A 0535+26 during the outburst. We complete spectral and timing analyses of the data. We study the evolution of the pulse period, present energy-dependent pulse profiles both at the initial pre-outburst flare and close to the outburst maximum, and measure how the cyclotron resonance-scattering feature (hereafter CRSF) evolves. We present three main results: a constant period $P = 103.3960(5)$ s is measured until periastron passage, followed by a spin-up with a decreasing period derivative of $\dot{P} = (-1.69 \pm 0.04) \times 10^{-8}$ s/s at MJD 53618, and P remains constant again at the end of the main outburst. The spin-up provides the evidence for the existence of an accretion disk during the normal outburst. We measure a CRSF energy of $E_{\rm cyc} \sim 50$ keV during the pre-outburst flare, and $E_{\rm cyc} \sim 46$ keV during the main outburst. The pulse shape, which varies significantly during both pre-outburst flare and the main outburst, evolves strongly with photon energy.

We argue that X-ray flaring variability observed in the transient X-ray pulsar A 0535+26 is due to a low-mode magnetospheric instability. This instability develops at the onset of accretion, in a thin boundary layer between the accretion disk and neutron star magnetosphere. As a result, the matter collected in the boundary layer can rapidly fall onto the neutron star surface close to the magnetic poles, but not exactly along the field lines by which the stationary accretion proceeds. This explains the shift in the cyclotron line energy measured using RXTE data in a pre-outburst spike, with respect to the line energy observed during the main outburst. Furthermore, the instability can account for the difference in pulse profiles, and for their energy evolution that is different in the pre-outburst flare and the main outburst.