Warped disks and super-Eddington flows in X-ray binaries as an analogue to AGN accretion physics

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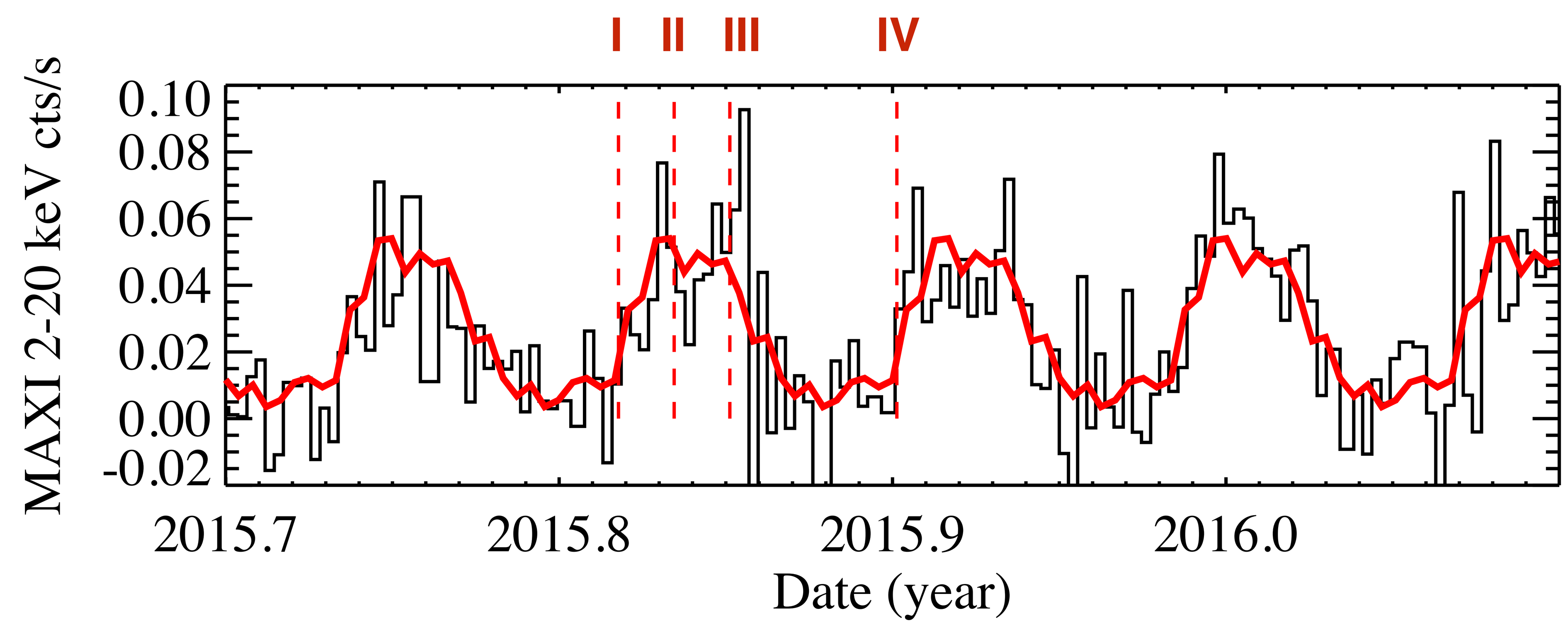
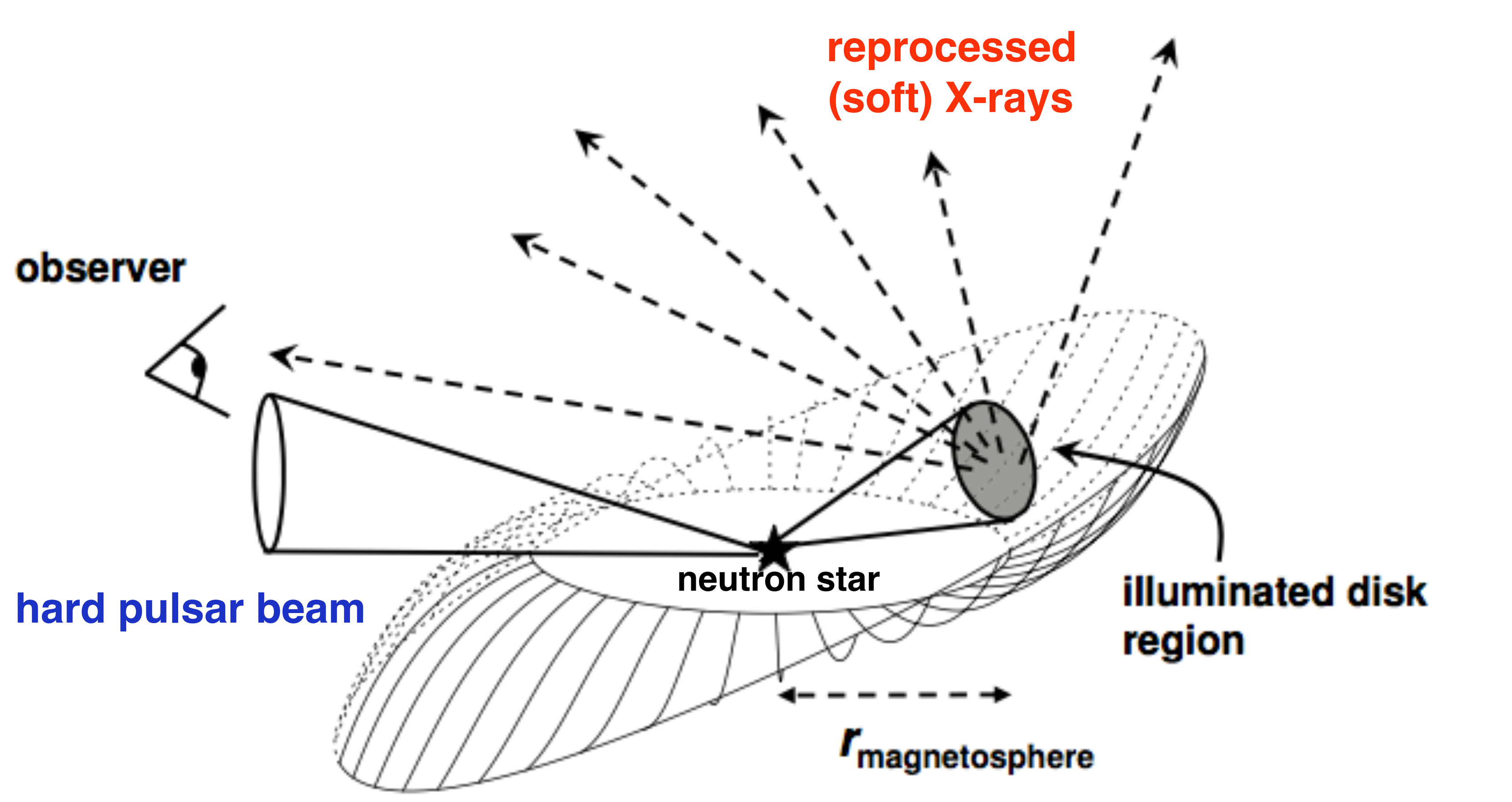
1. Observations

LMC X-4 is a bright (L_X ~ 2 x 10^{38} erg/s) neutron star X-ray binary with a 1.4 day orbital period and a 13.5 second spin period. The source displays a 30 day modulation in brightness called a superorbital period, which is believed to be caused by a warped, precessing inner accretion disk. **In order to examine the geometry and kinematics of the inner disk precession**, we used the hard X-ray telescope *NuSTAR* and the soft X-ray telescope *XMM-Newton* to observe LMC X-4 jointly at four points in a single superorbital cycle in 2015. **Understanding warped accretion disks in X-ray binaries can lead to insights about similar disks in AGN**, such as the Circinus Galaxy and NGC 4258.

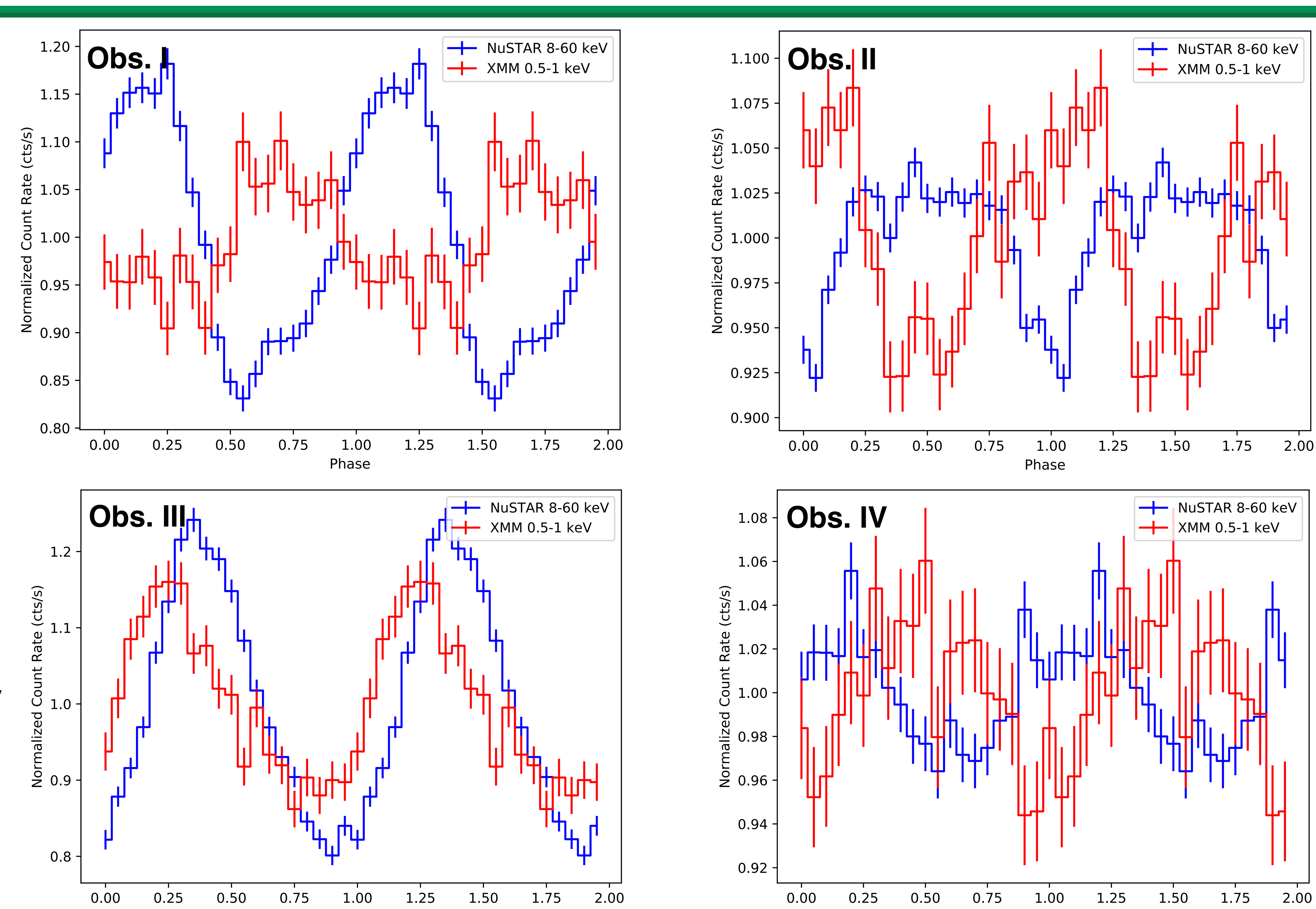


2. Precession of a warped disk



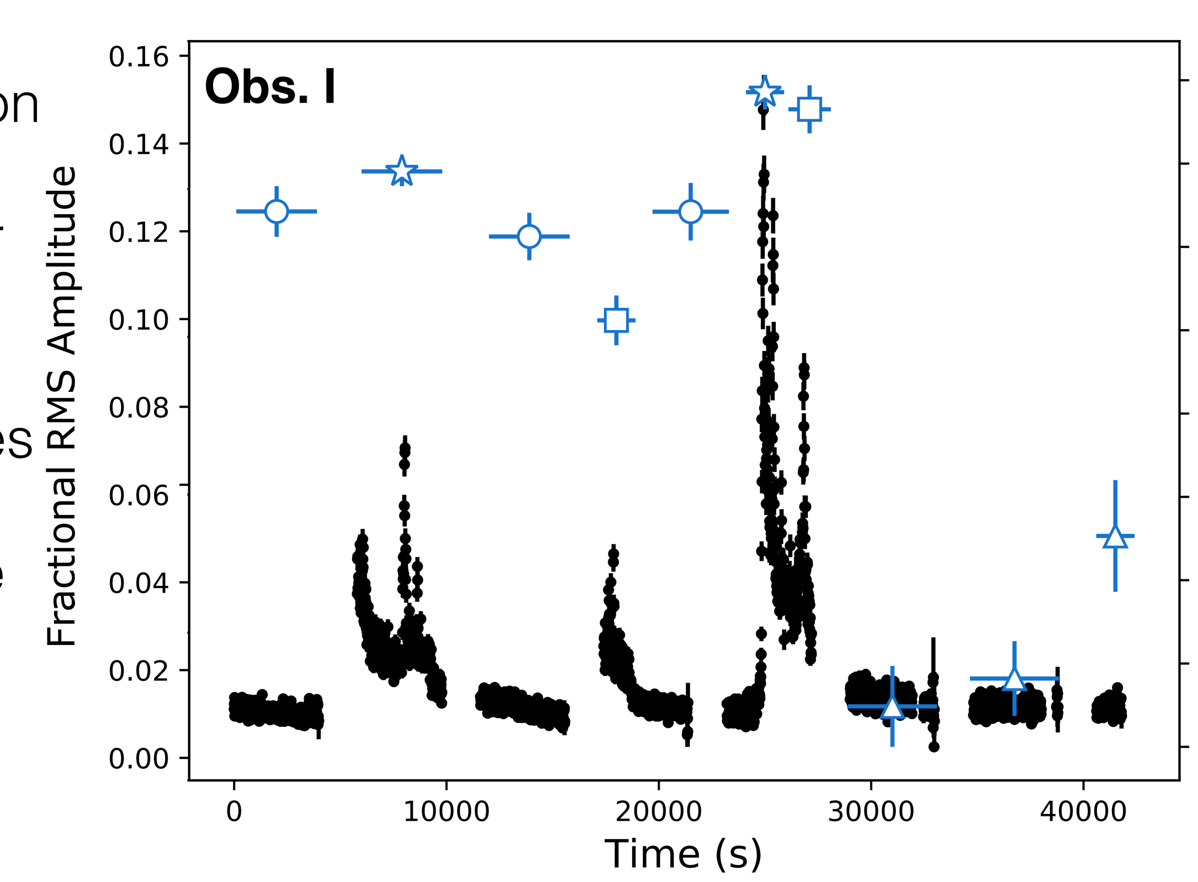
from Hickox & Vrtilek (2005)

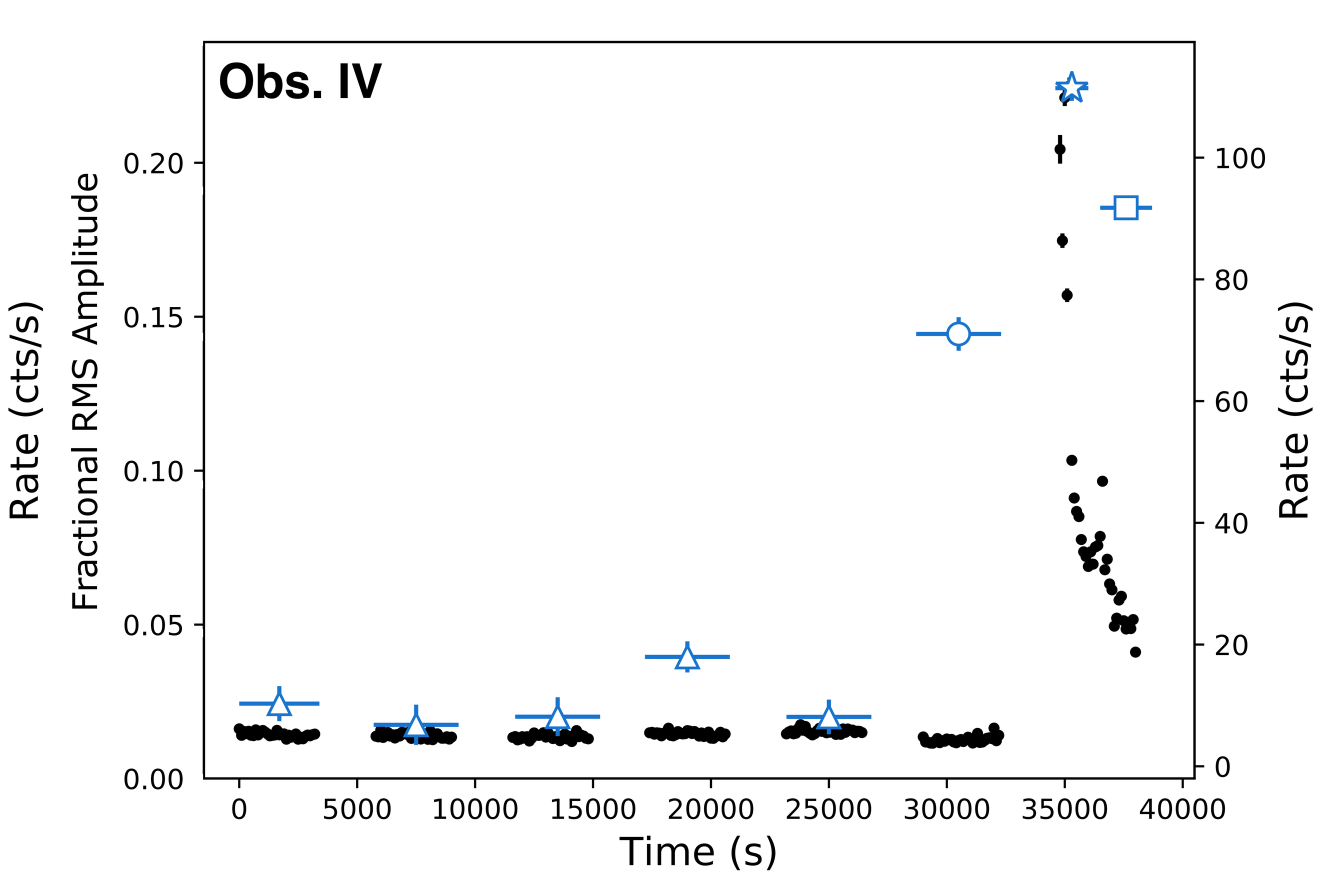
The geometry of the warped inner disk creates a unique opportunity to study disk precession. The warped is irradiated by the pulsar beam, allowing the observer to see both hard pulses directly from the beam and soft pulses from the disk. Using NuSTAR and XMM to separate the hard and soft pulsations, **we observe a relative phase shift between hard and soft pulsations that indicates disk precession.**



3. Pulsation dropout and turn on

Observations I and IV in this series, which occur at superorbital phase ~ 0.8, both show bright accretion flares during which LMC X-4 reaches super-Eddington luminosities of L_X = 1-2 x 10^{39} erg/s. Our timing analysis revealed that the pulse strength increases dramatically in time intervals preceding the flares, and drops out afterwards. These changes in strength are accompanied by phase shifts in the pulse profiles during the flaring events. **We believe that the onset of super-Eddington accretion could be changing the emission geometry of LMC X-4, making it an excellent comparison for super-Eddington accretors.**





References and Acknowledgements

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