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Investigating the origin of Quasi-Periodic Oscillations in Black hole X-ray binaries

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Abbreviated Abstract: The X-ray flux from accretion discs in galactic black hole X-ray binaries is known to possess a dynamic variability on time scales of msec to hours. If we turn to the Fourier space, the power density spectrum presents a broadband noise and peaked features known as Quasi-periodic oscillations (QPOs). In our work, we present a technique to identify the radiative component that can produce such QPOs by modelling their temporal properties and apply it to a black hole X-ray binary- MAXI J1535-571, observed to have strong low-frequency QPO by *AstroSat*. Its energy spectra suggests emission from truncated outer disk and a thermal comptonizing corona in the inner regions. We find that the variations in accretion rate, truncated disk radius and coronal heating rate with time delays between them can explain the QPOs.

Related Publications:

Garg et al., MNRAS (in press), astro-ph: 2008.06468 (2020)
Maqbool et al., MNRAS, 486, 2964 (2019)

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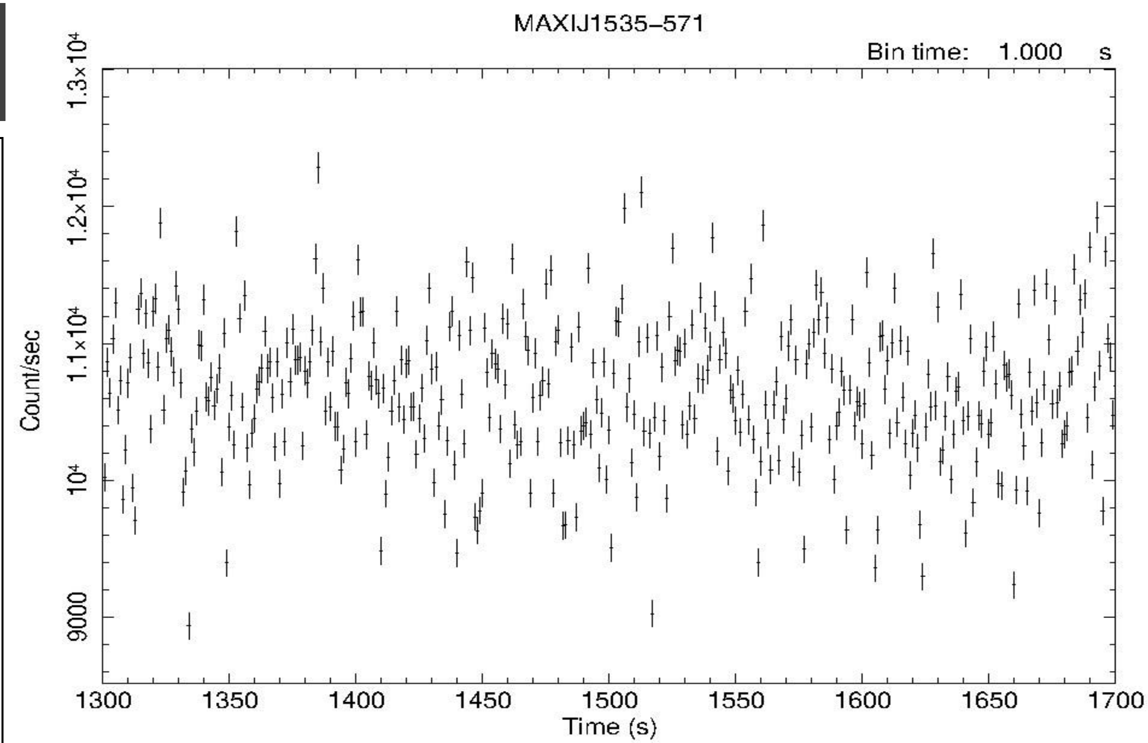
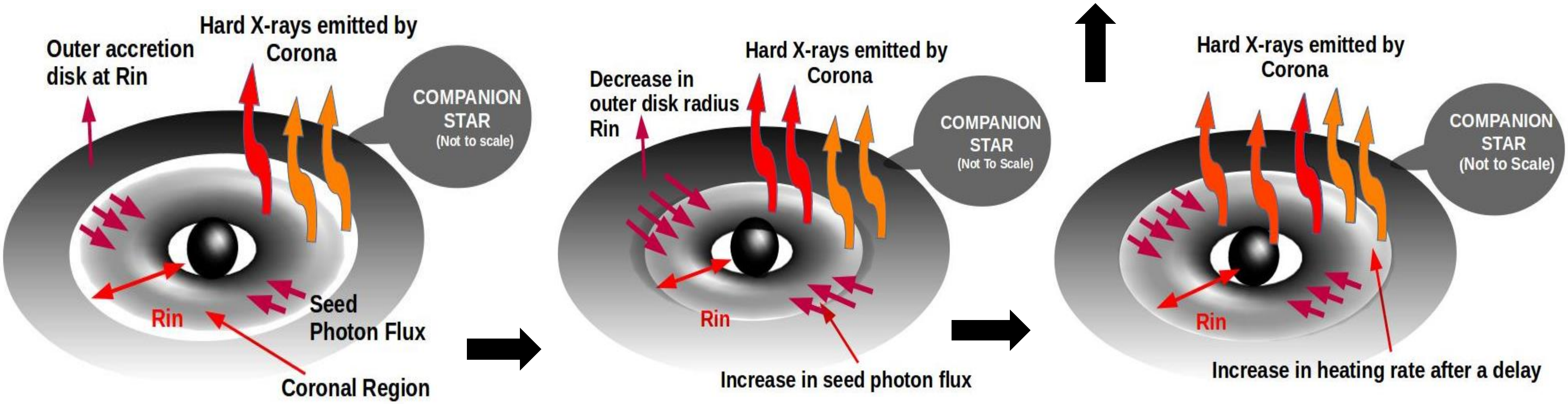
Black Hole X-ray Binary

- **Stellar Binary system containing a <u>Normal star</u> and a <u>Black Hole.</u>**
- **Black hole accretes matter from normal star and forms <u>Accretion disk</u>.**
- **Extraction of gravitational potential energy in form of X-rays.**



Typical Light curve received



Spectral Behavior

Using *XSPEC*, time averaged spectrum of a BHXB can be modelled by:

1. DISKBB

BLACKBODY EMISSION IN OUTER DISK.

KT_{in} ⇔ Accretion rate.

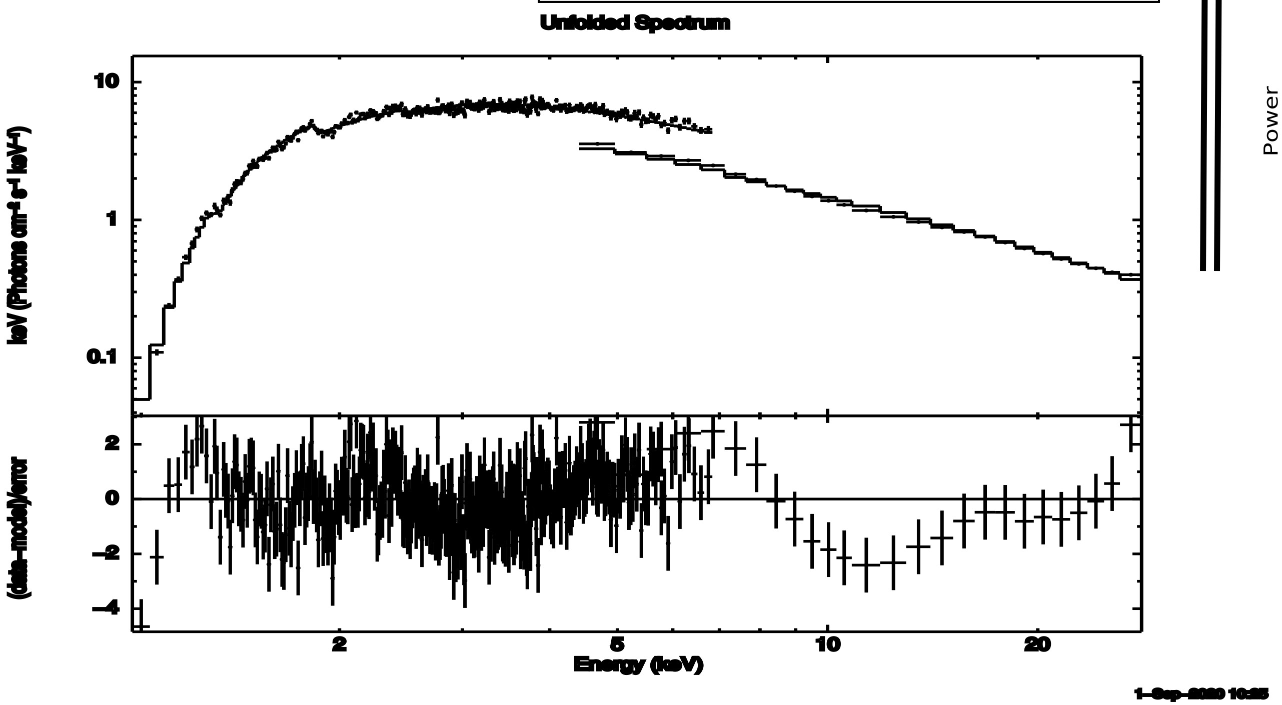
N_{dbb} ⇔ Inner disk radius.

2. THCOMP

THERMAL COMPTONIZED CONTINUUM.

KT_e ⇔ Coronal heating rate.

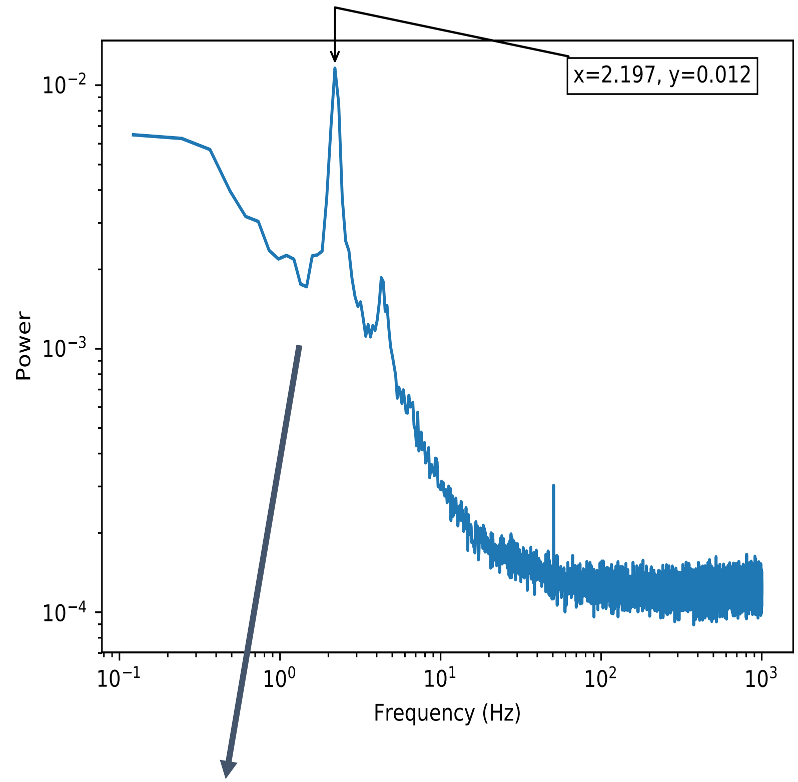
Gamma ⇔ Optical depth.



Photon spectrum in the 1.0-30.0 keV

Power Density Spectrum

Amplitude Squared of Fourier transform of light curves.



QPO seen in the PDS at 2.197 Hz.

Modelling the Temporal Behavior

VARIATION OF THE SPECTRUM

$$\Delta F(E) = \sum_{j=1}^{M} \frac{\partial F(E)}{\partial \alpha_j} \Delta \alpha_j$$

Where F(E) is the steady state Spectrum, α are the parameters M is the number of parameters.

Fractional r.m.s. $= (1/\sqrt{2})|\Delta F(E)|/F(E)$,

Phase-lag, $\phi =$ Argument of $[\Delta F(E_{ref})^{*} \Delta F(E)]$.

CONCLUSIONS

- **Accretion rate is the primary driver of the phenomenon.**
- **Variations in accretion rate is followed by variations in the inner disk radius and after a time delay, coronal heating rate varies, leading to the production of QPOs.**

COMPARISON WITH ASTROSAT OBSERVATIONS OF MAXI J1535-571