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Fast multi-wavelength broad-band and QPO variability in a black hole X-ray binary: an accretion flow and/or a jet origin?

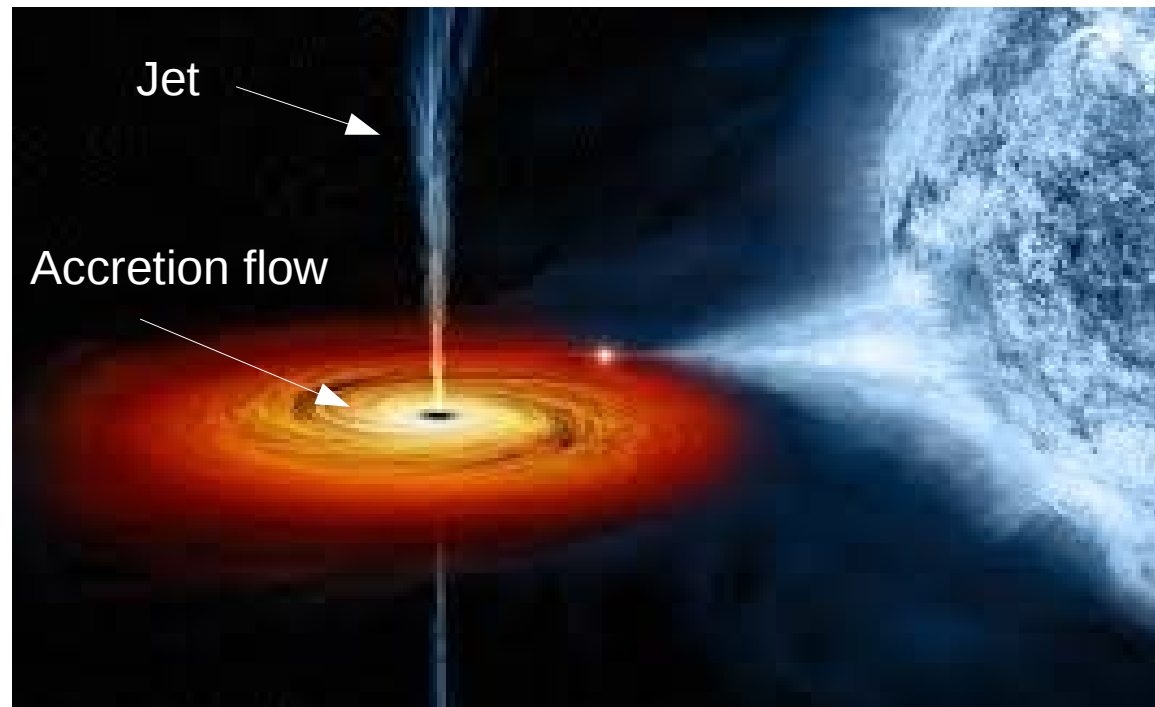
Maithili Kalamkar



Rome Astronomical Observatory

P. Casella, P. Uttley, K. O'Brien, T. Maccarone,
F. Vincentelli, M. van der Klis

Emission components of a black hole X-ray binary



Emission from various components:

Jet

Synchrotron emission:
radio through optical-
infra-red (OIR) and
possibly in X-rays

Accretion disc

Thermal emission:
inner disc soft X-rays
outer disc to UV & op.

Hot flow/corona

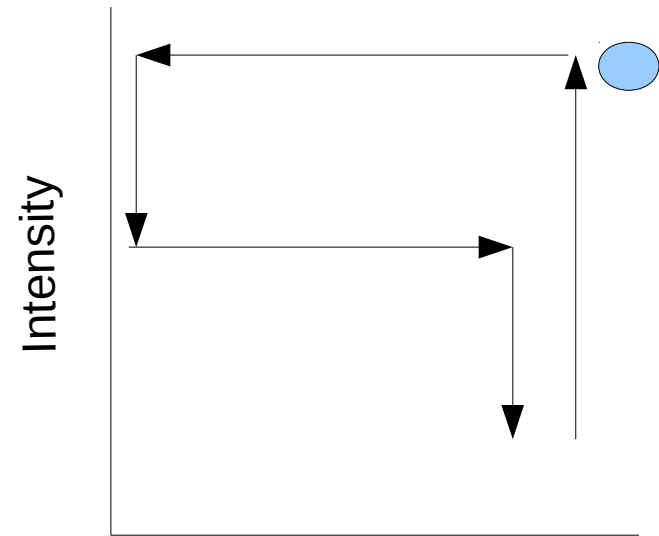
Comptonized emission:
hard X-rays
also suggested to emit
in OIR

GX 339-4

Outburst in 2010

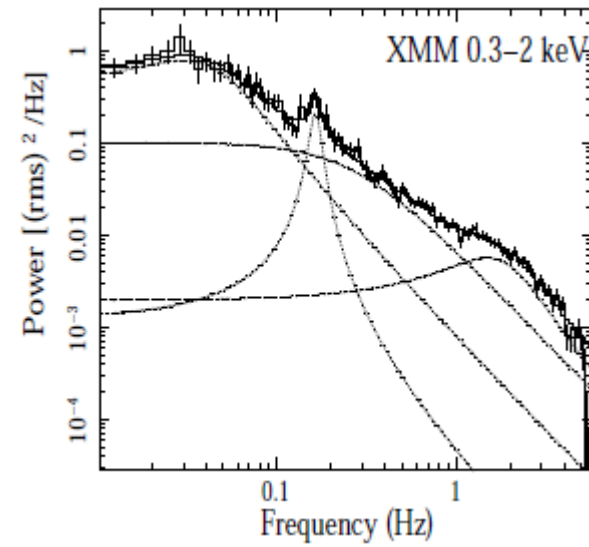
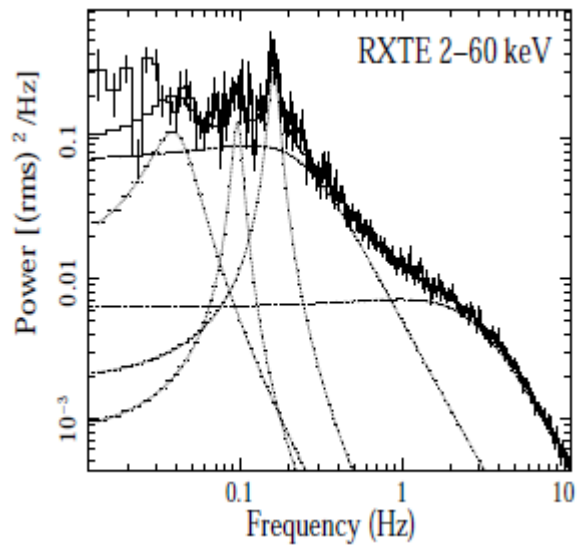
Simultaneous observations:

- | | |
|-------------------------------|------------|
| 1. RXTE: X-rays | 2-60 keV |
| 2. XMM-Newton: X-rays | 0.3-10 keV |
| 3. XMM-Newton Optical monitor | |
| U band (344 nm) | 3.6 eV |
| V band (543nm) | 2.3 eV |
| 4. VLT ISAAC: IR | |
| K band (2.2 μm) | 0.5 eV |

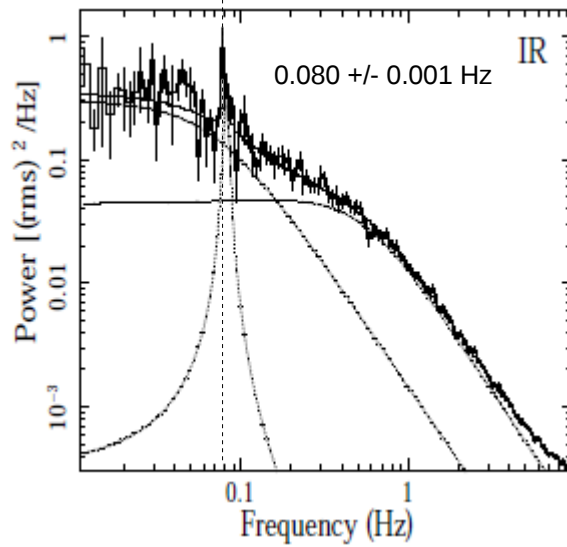
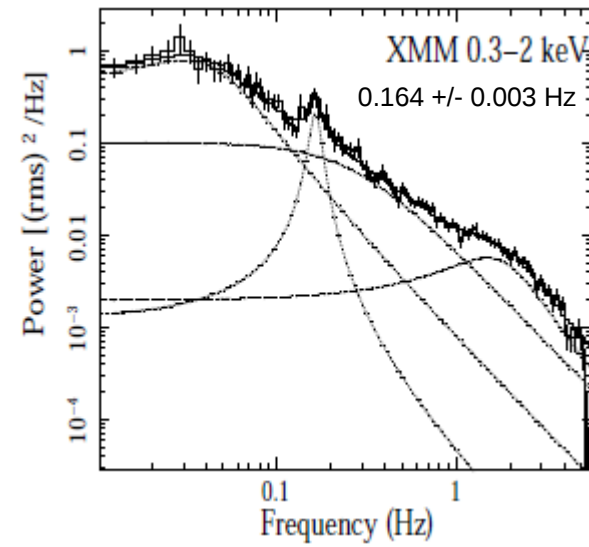
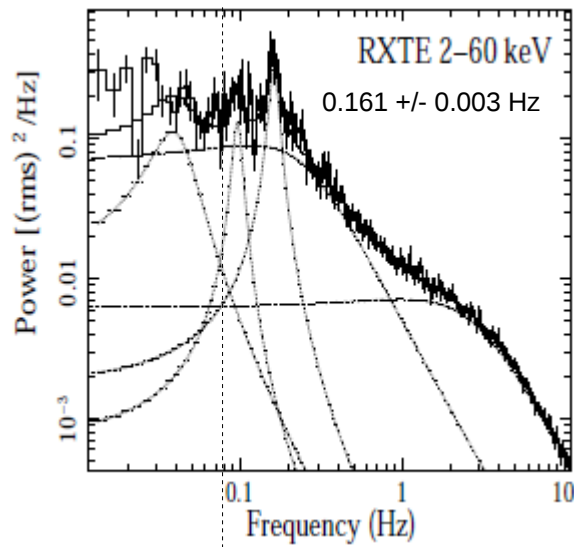


Hardness
Hardness- Intensity Diagram

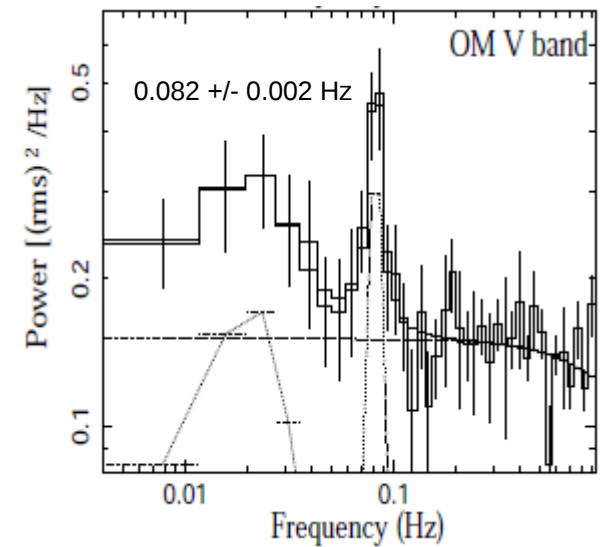
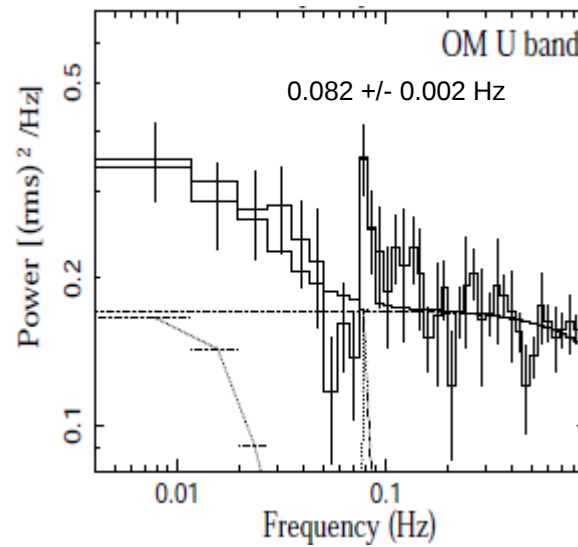
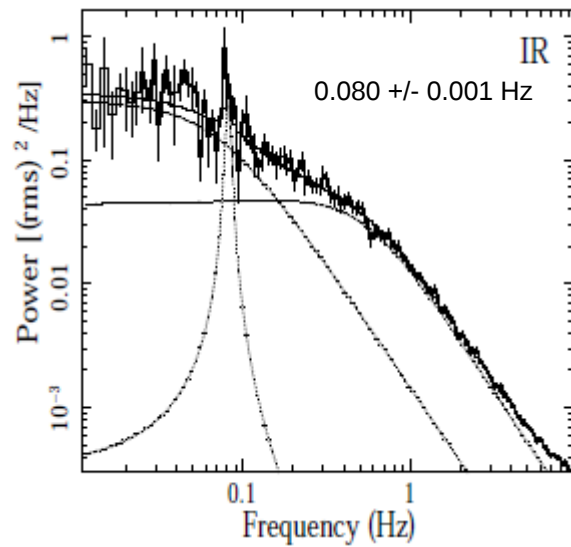
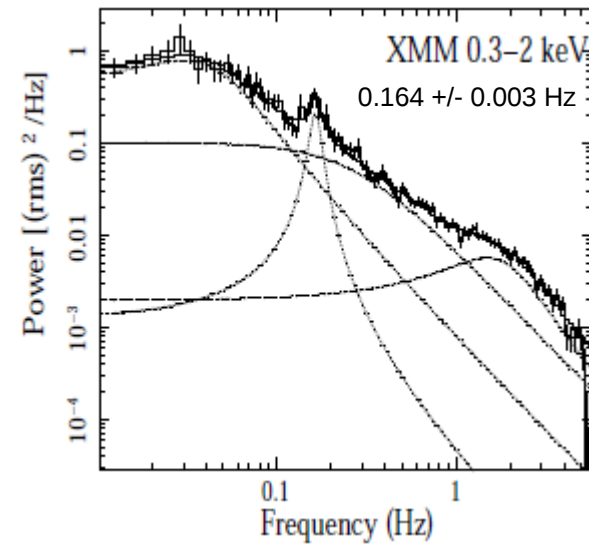
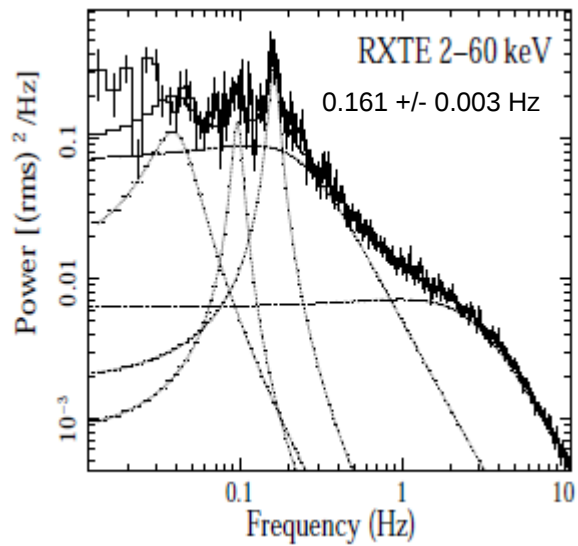
Power density spectra



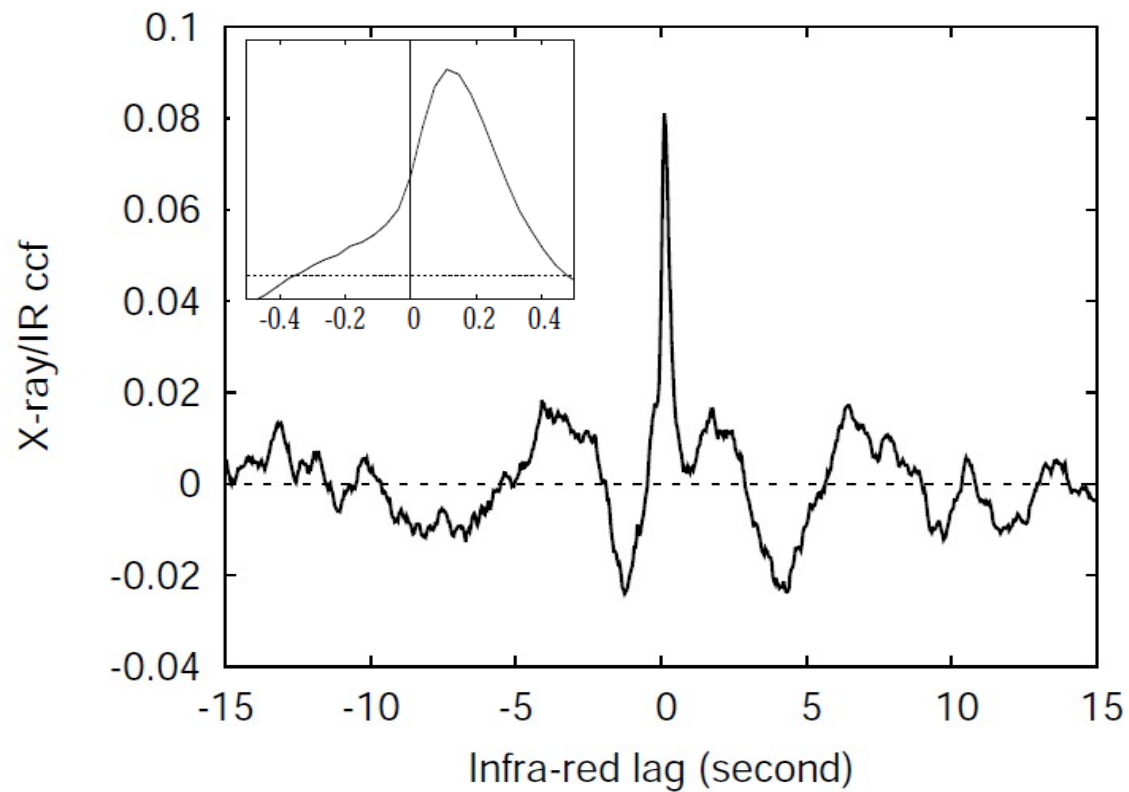
Power density spectra



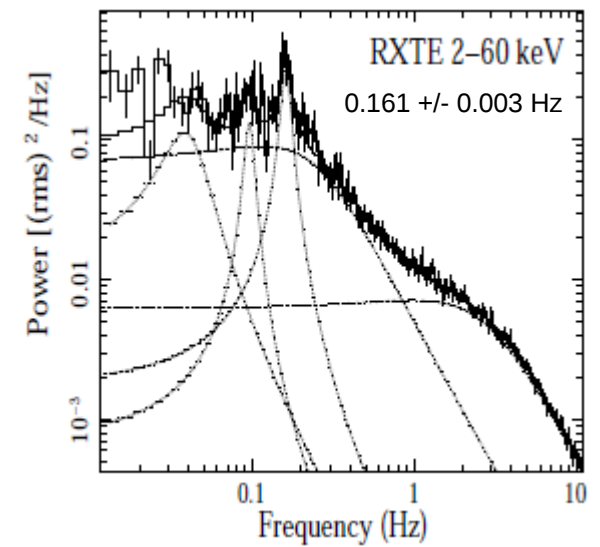
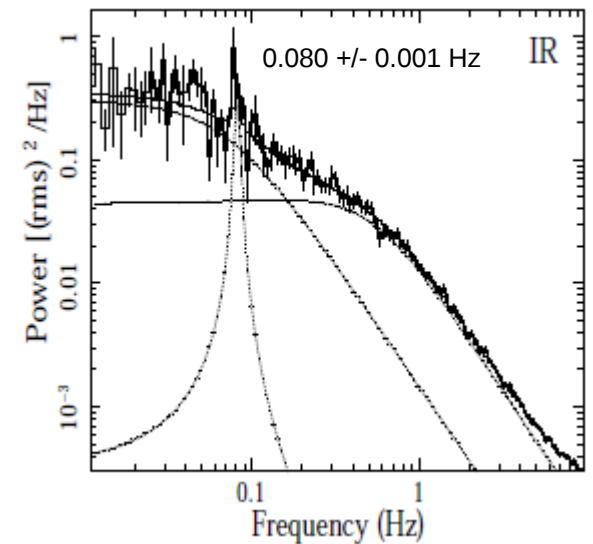
Power density spectra



Cross correlation function

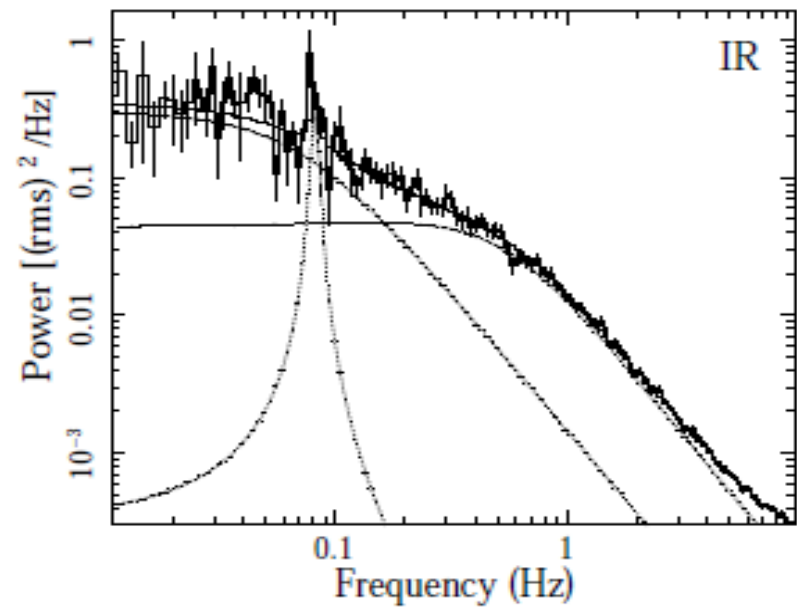
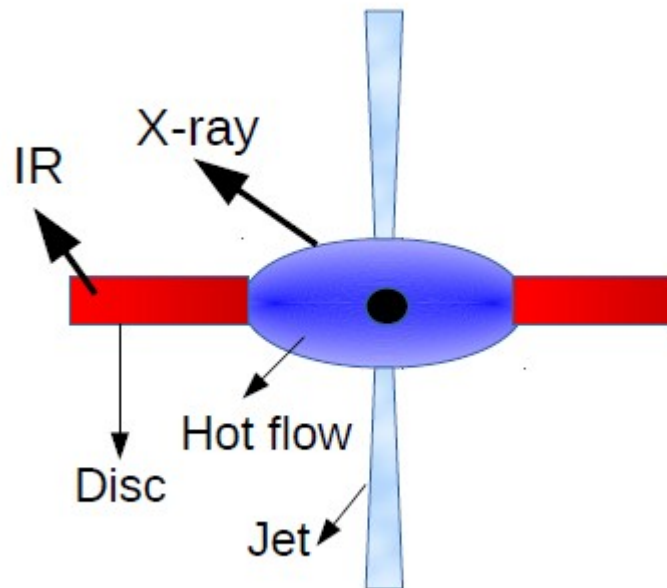


IR lags the X-rays by 111 ms



Origin of variable IR emission

Intrinsic outer disc emission?

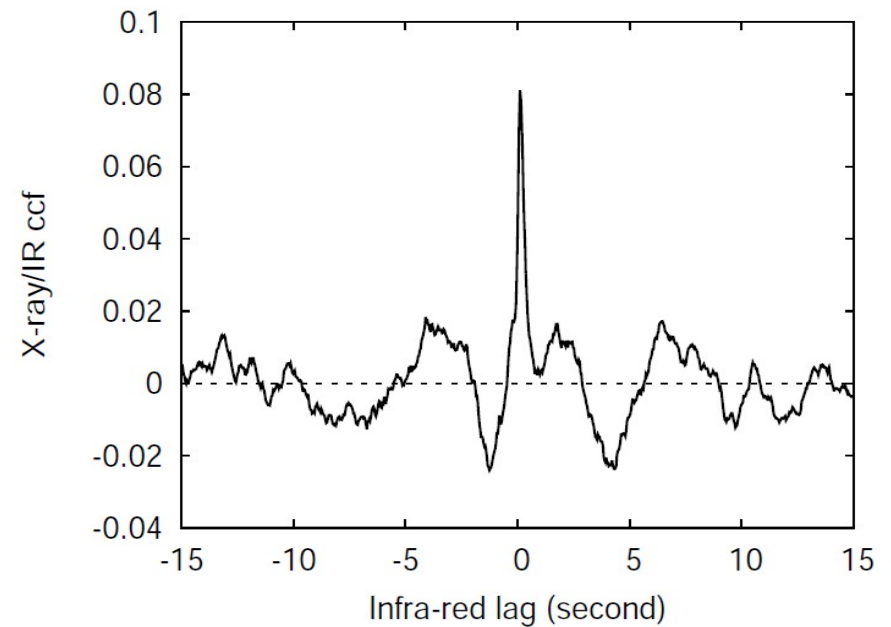
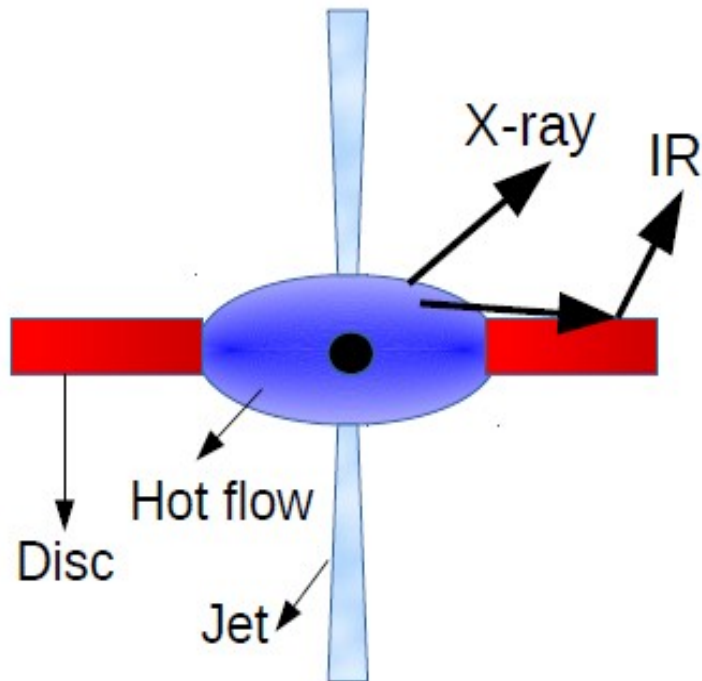


Origin of variable IR emission

X Intrinsic outer disc emission?

Variability time scales are too fast

Reprocessing of variable X-ray emission incident on outer disc?



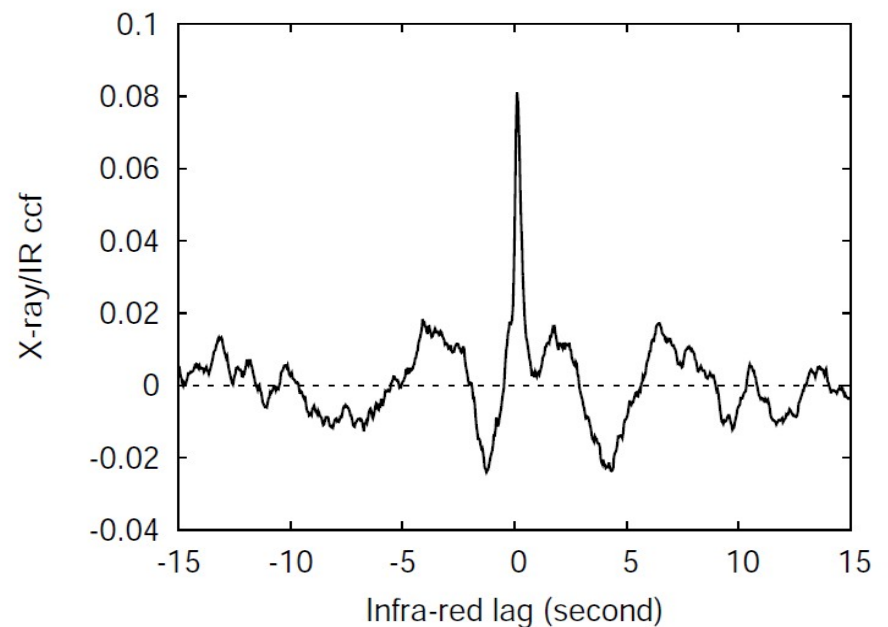
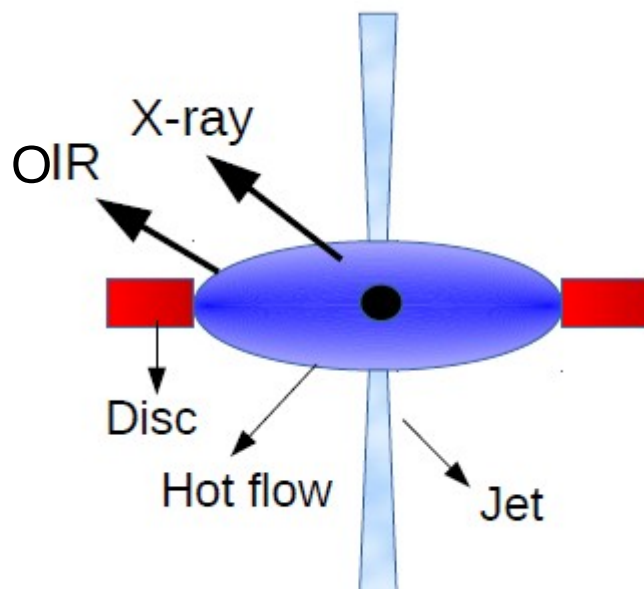
Origin of variable IR emission

- X** Intrinsic outer disc emission?
- X** Reprocessing of variable X-ray emission incident on outer disc?

Variability time scales are too fast

Too short CCF delay
Highly inclined disc and a highly asymmetric CCF required

Synchrotron emission from outer hot flow?



Origin of variable IR emission

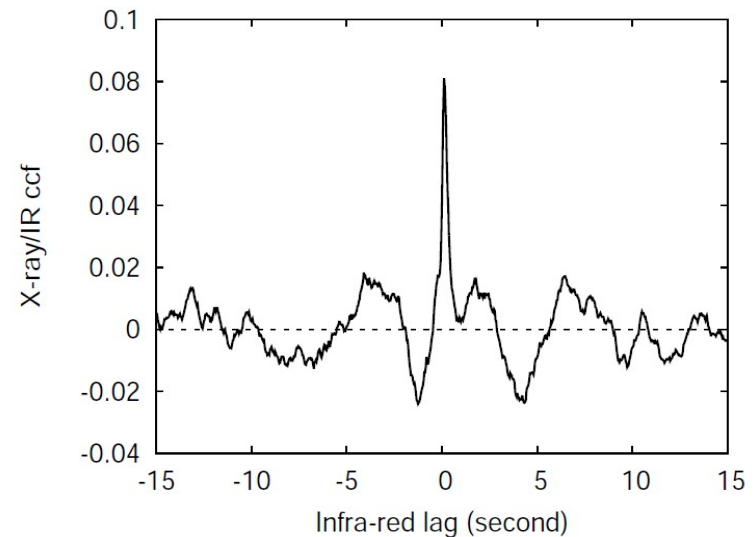
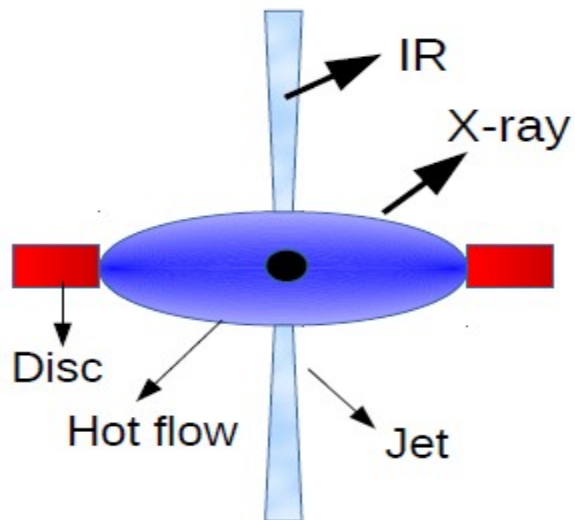
- X** Intrinsic outer disc emission?
- X** Reprocessing of variable X-ray emission incident on outer disc?
- X** Synchrotron emission from outer hot flow?

Variability time scales are too fast

Too short CCF delay
Highly inclined disc and a highly asymmetric CCF required

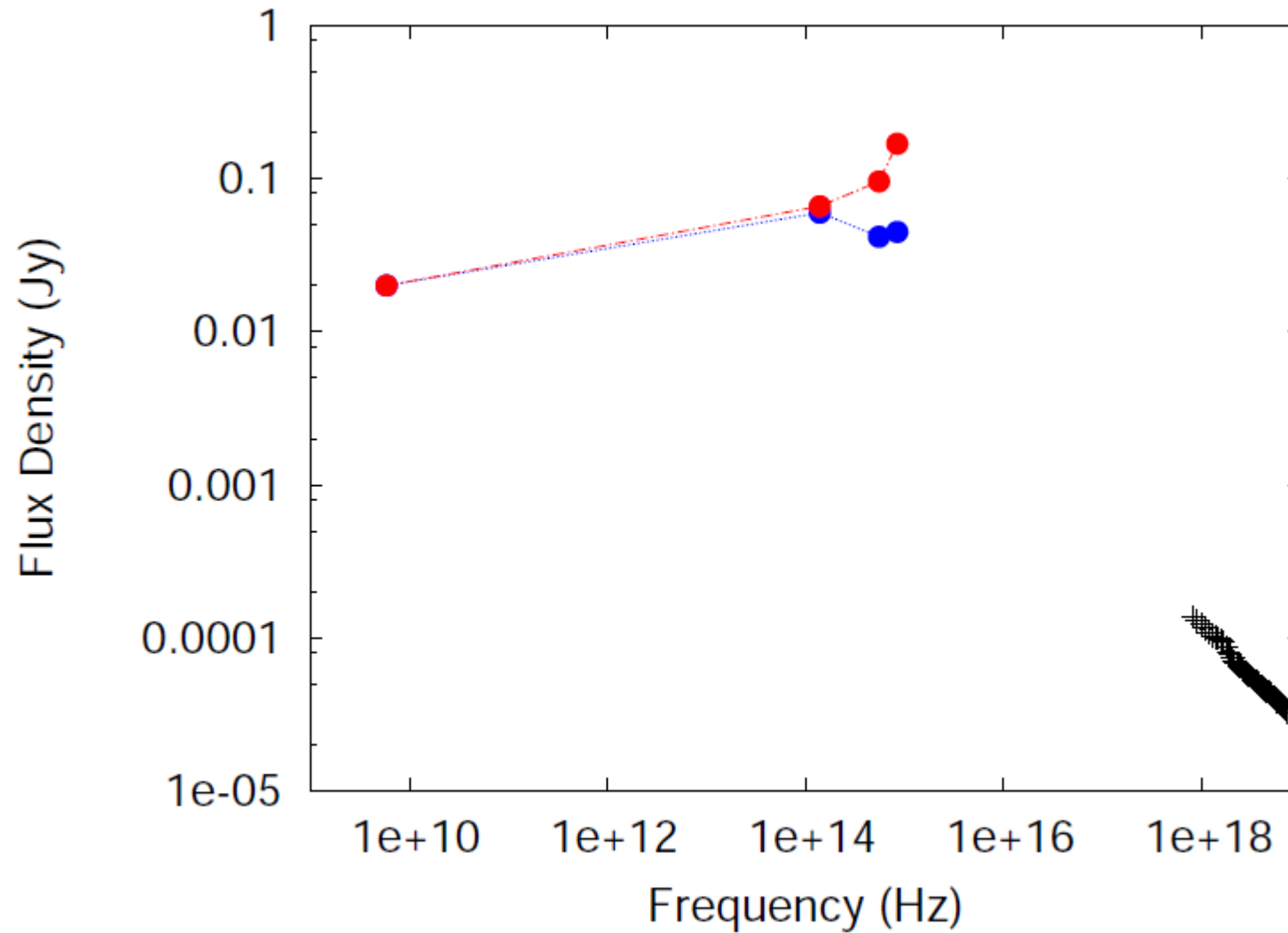
Unlikely

Synchrotron emission from the jet?

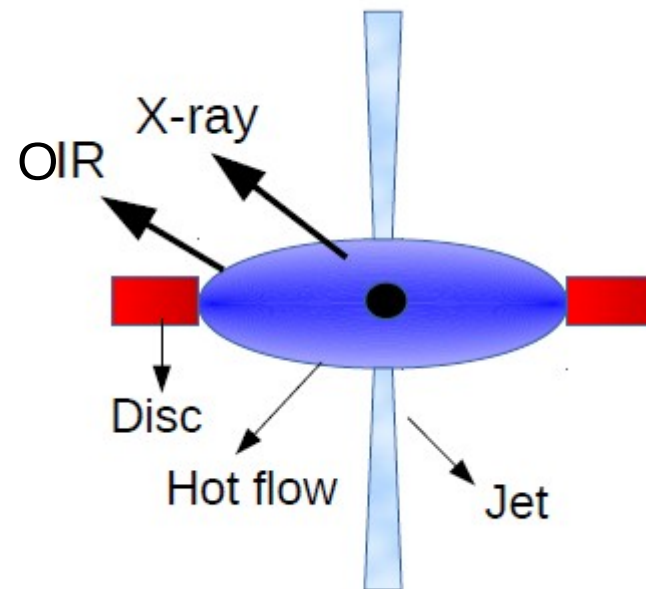
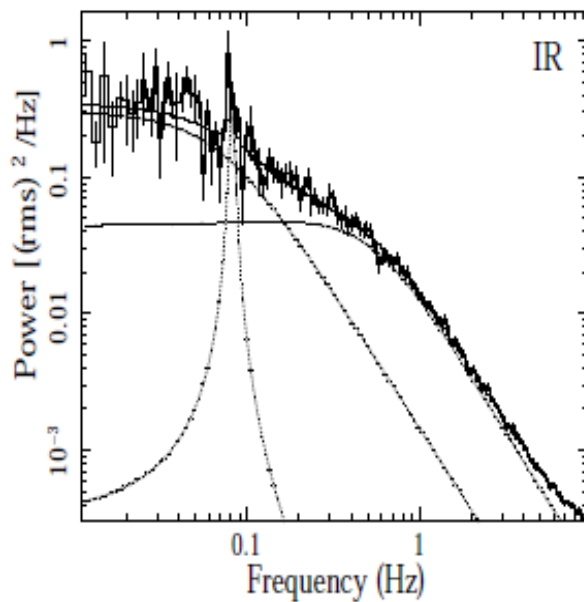
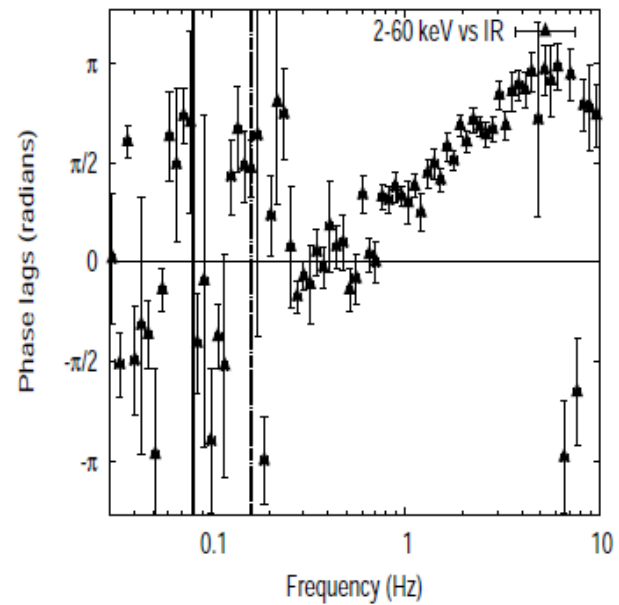
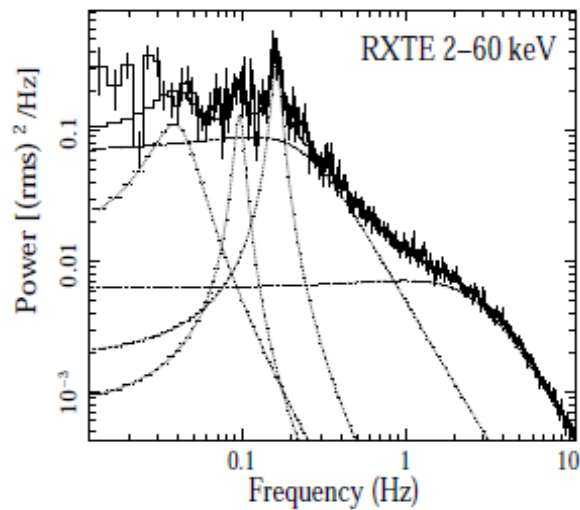


Origin of variable IR emission

Synchrotron emission from the jet?



Origin of the IR QPO



Conclusions

- First QPO detection in IR band in a black hole X-ray binary
- The IR and optical QPO are at half the frequency of the X-ray QPO
- The variable IR emission (broad band) is most likely jet emission
- The IR emission variable on the QPO time scale could be from Lense-Thirring precession of the hot flow – but this is difficult to reconcile with the broad band variability