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

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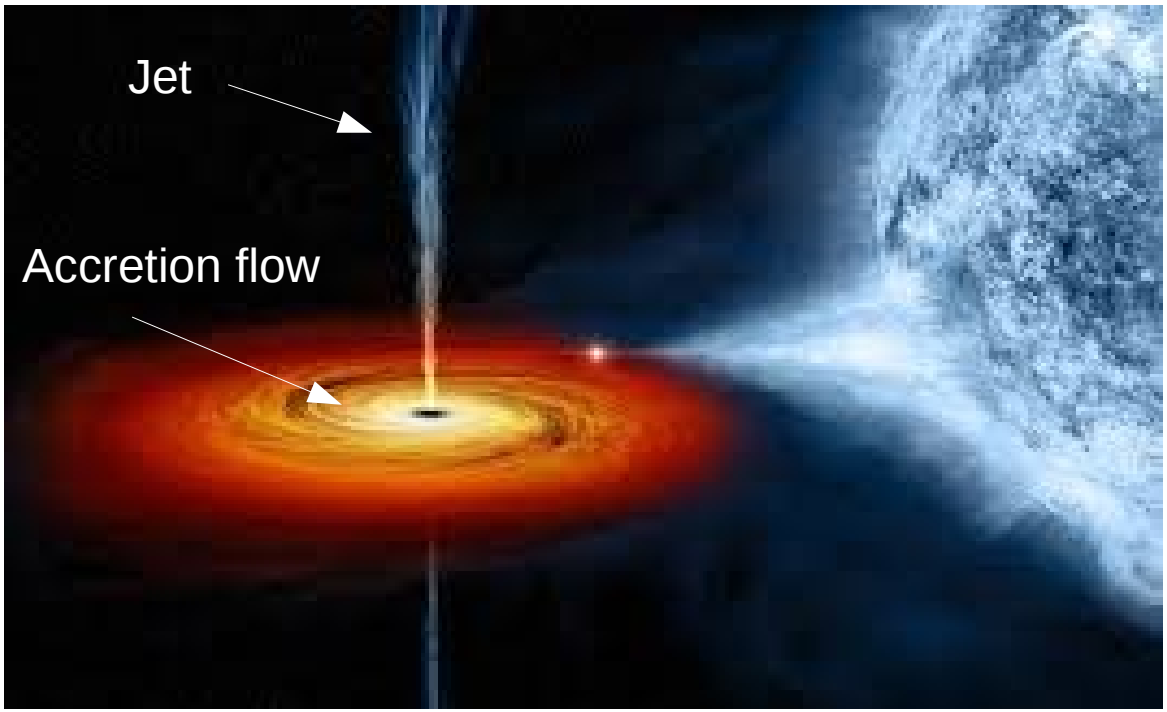
Emission components of a black hole X-ray binary



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

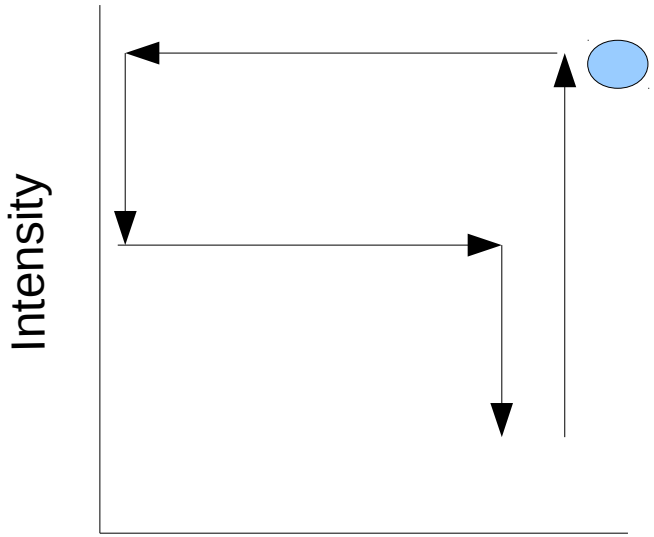
Simultaneous observations:

1. RXTE: X-rays 2-60 keV

2. XMM-Newton: X-rays 0.3-10 keV

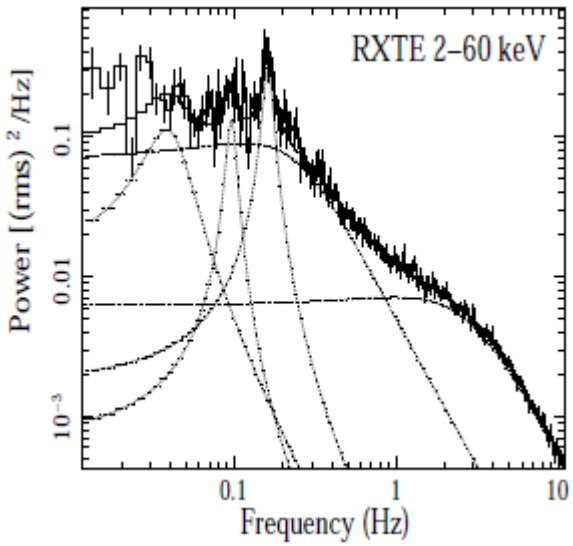
3. XMM-Newton Optical monitor
   U band (344 nm) 3.6 eV
   V band (543nm) 2.3 eV

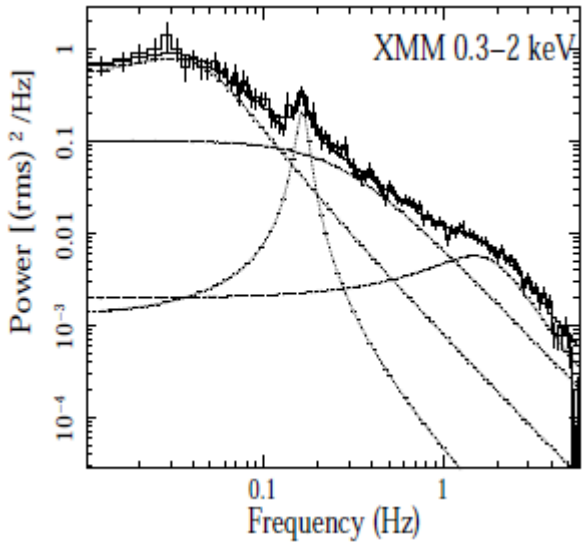
4. VLT ISAAC: IR
   K band (2.2 μm) 0.5 eV



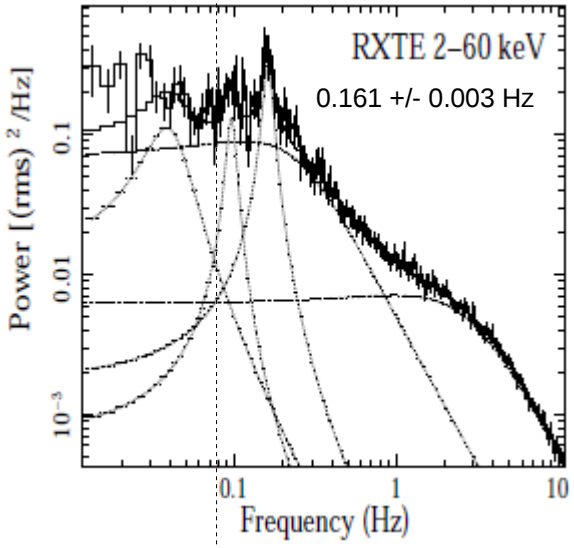
Hardness- Intensity Diagram

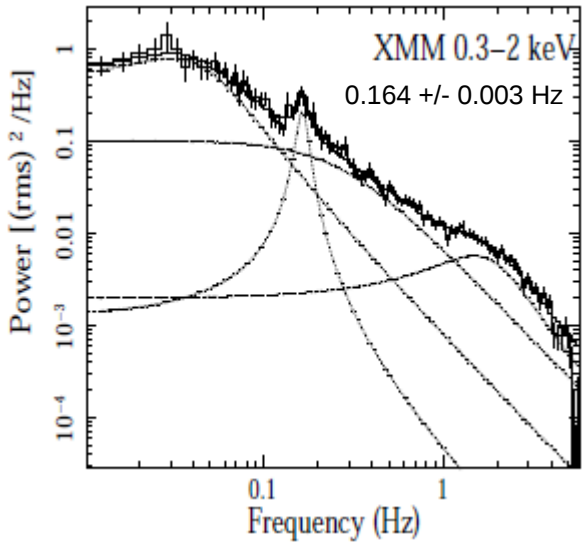
Power density spectra

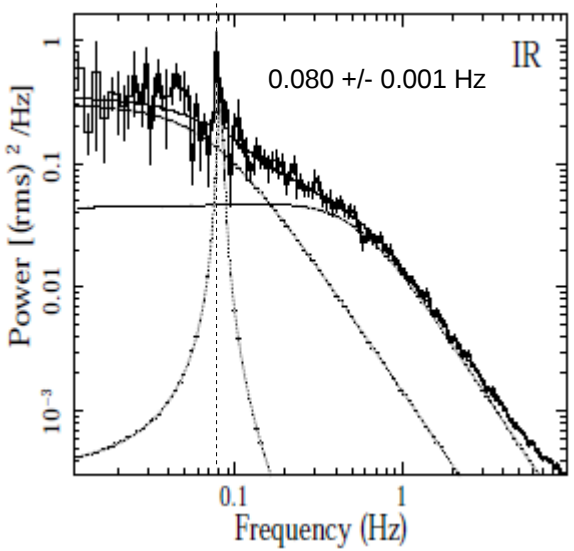




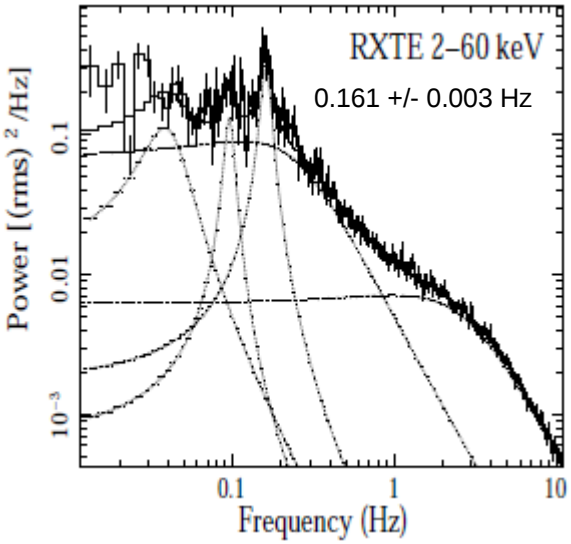
Power density spectra

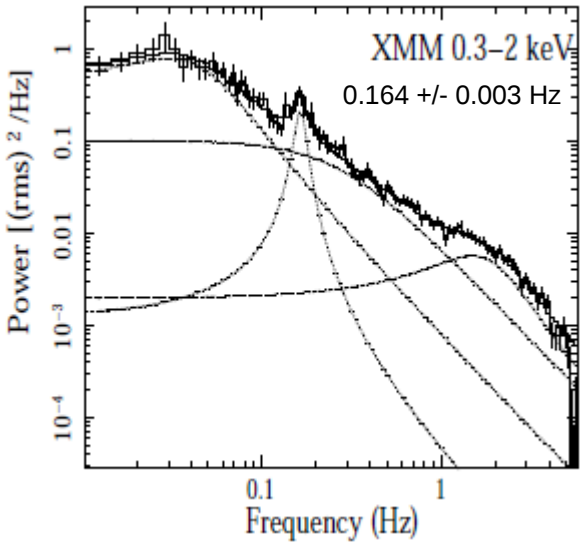


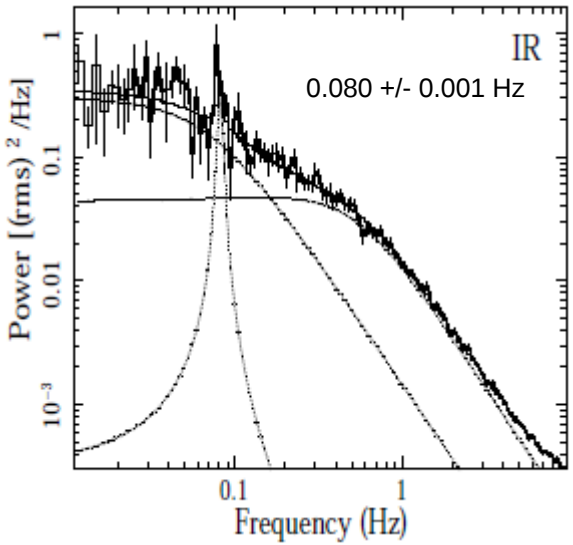


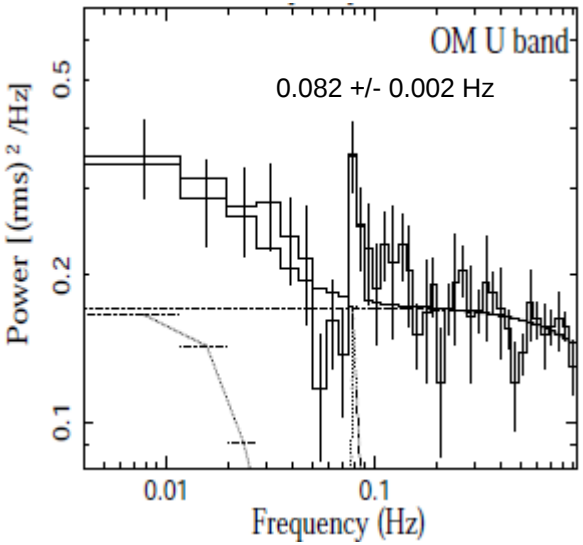


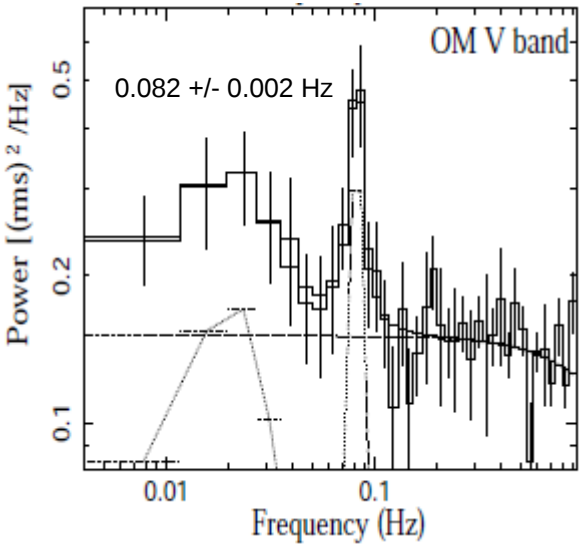
Power density spectra



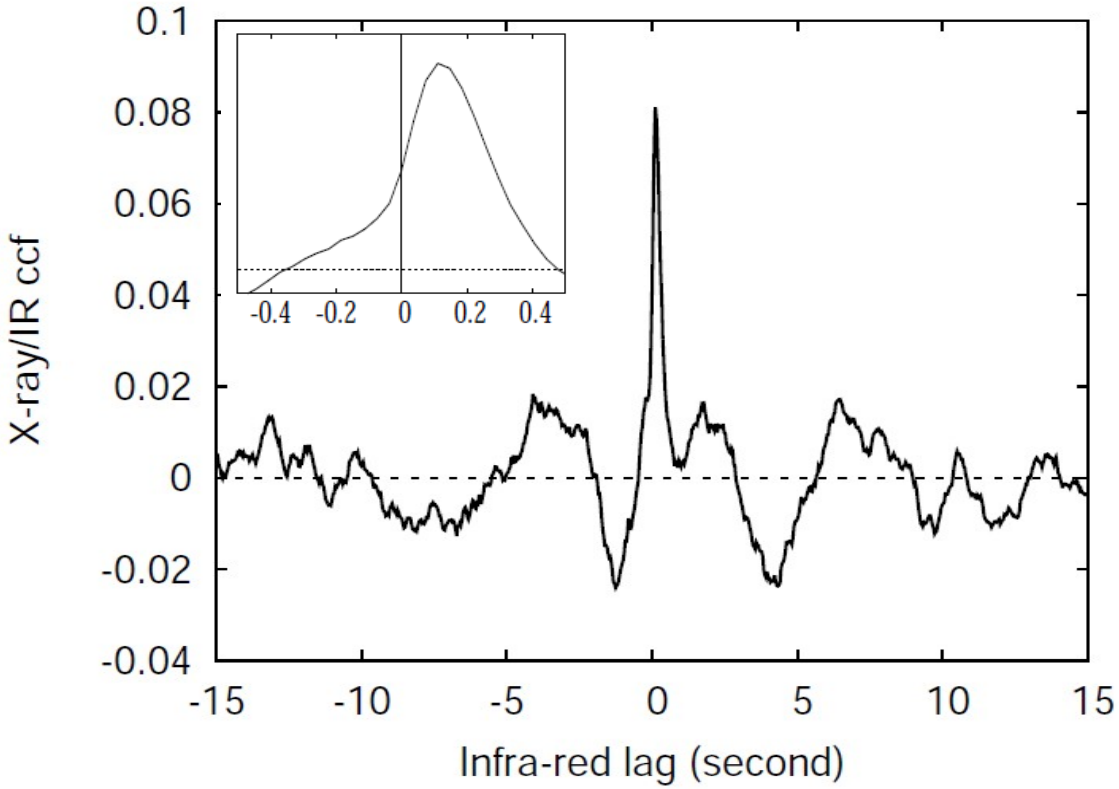




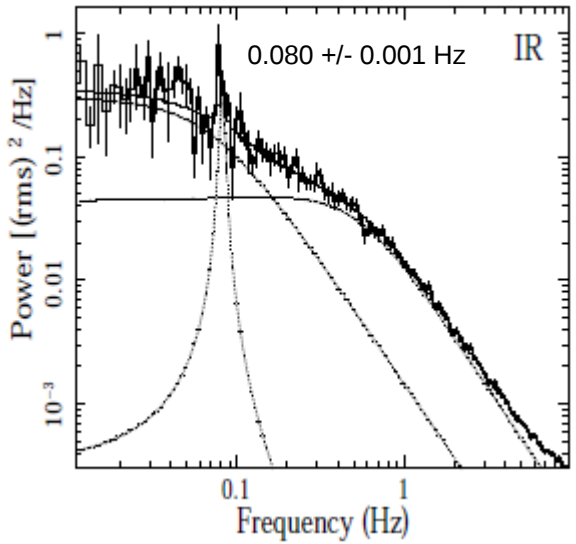


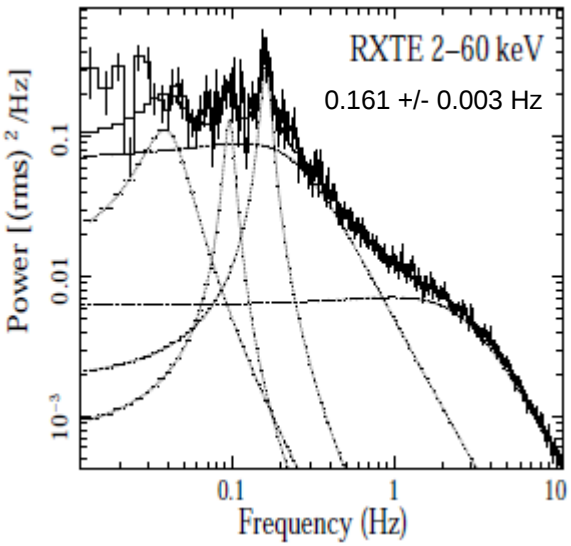


Cross correlation function



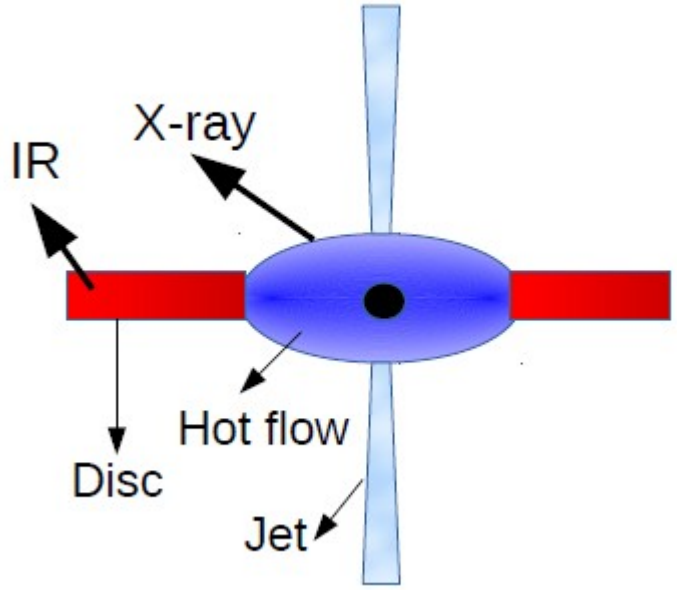
IR lags the X-rays by 111 ms

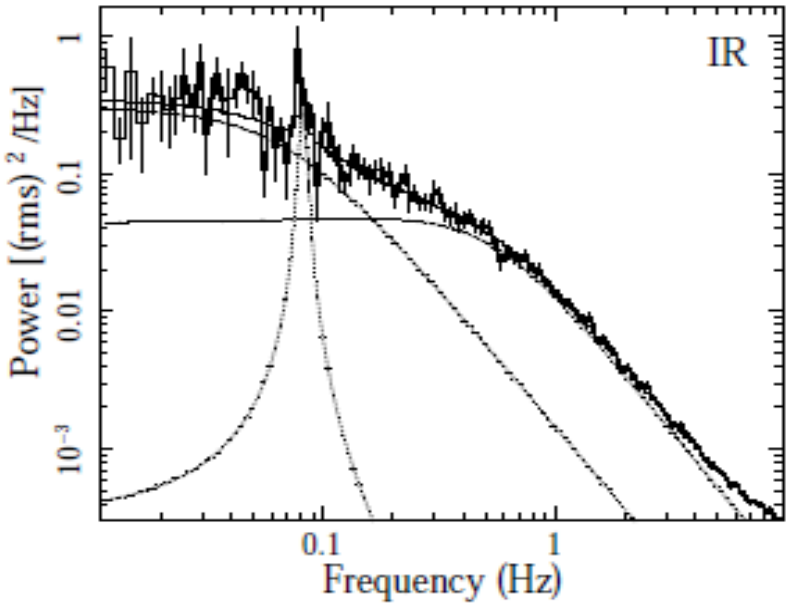




Origin of variable IR emission

Intrinsic outer disc emission?

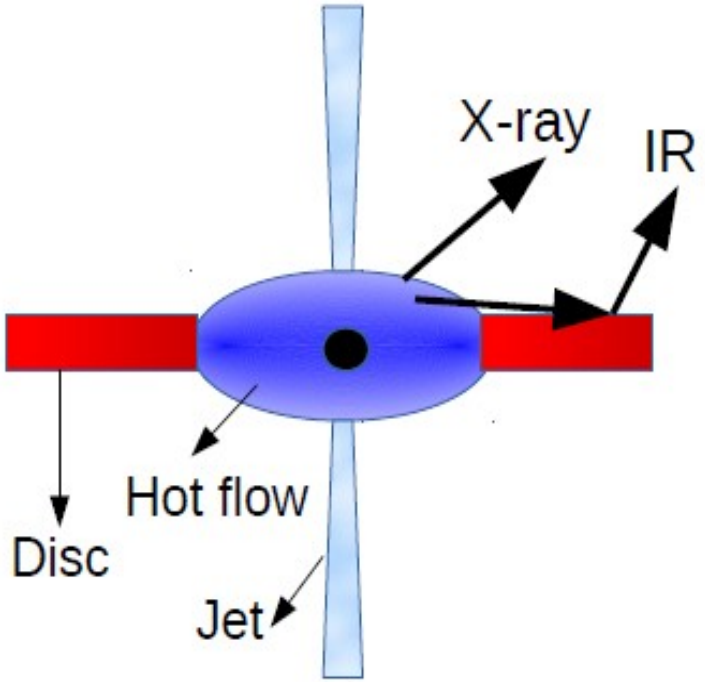


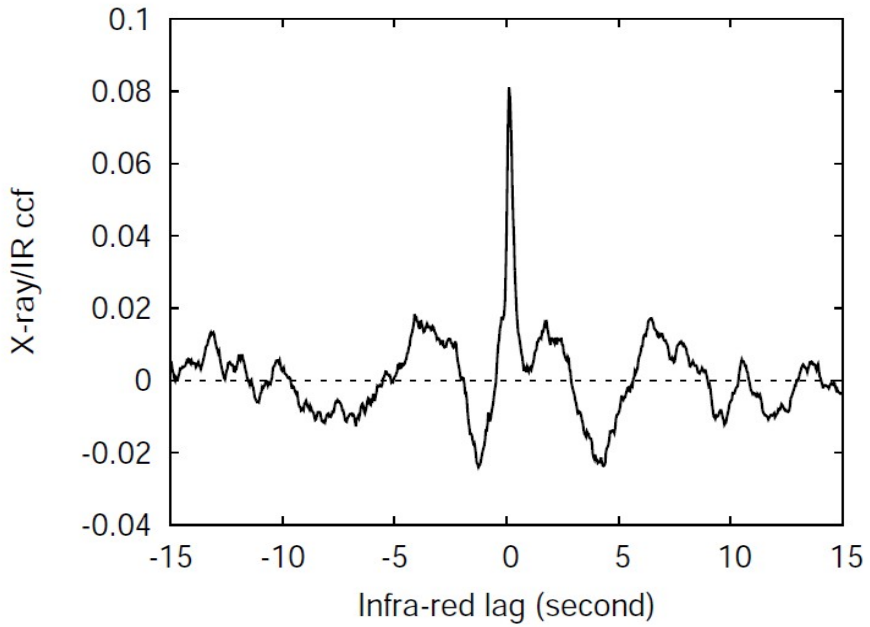


Origin of variable IR emission

✗ Intrinsic outer disc emission? Variability time scales are too fast

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

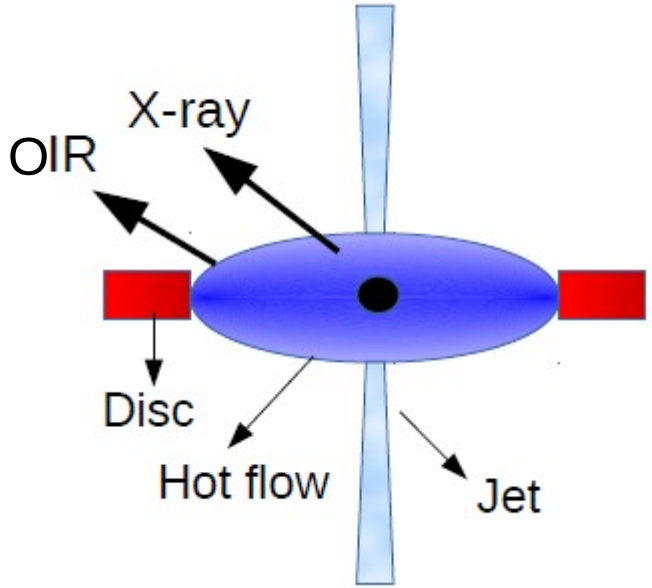


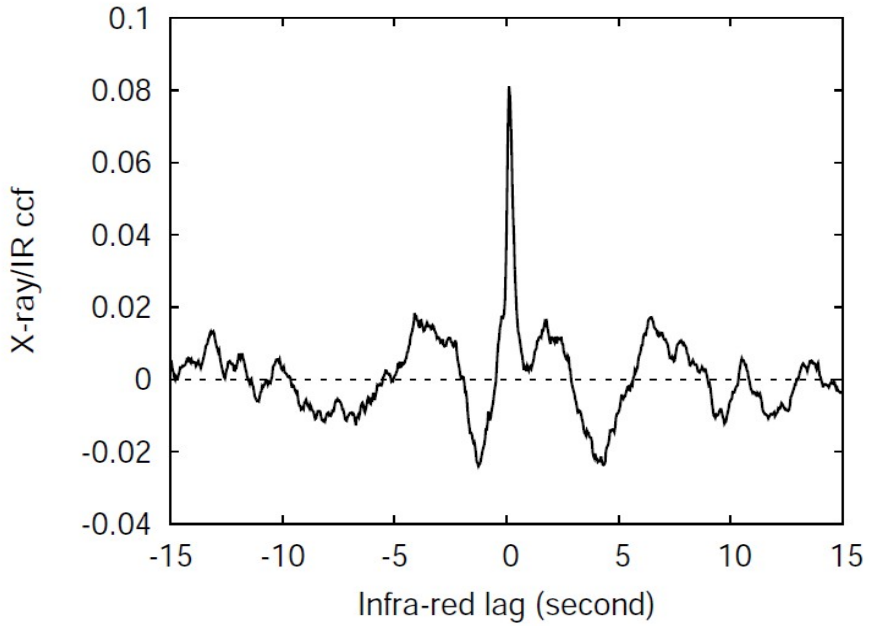


Origin of variable IR emission

- ✗ Intrinsic outer disc emission? — Variability time scales are too fast
- ✗ Reprocessing of variable X-ray emission incident on outer disc? — Too short CCF delay; Highly inclined disc and a highly asymmetric CCF required

Synchrotron emission from outer hot flow?

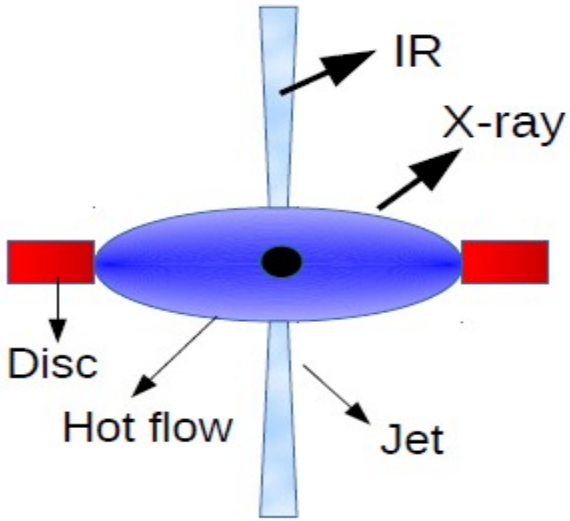


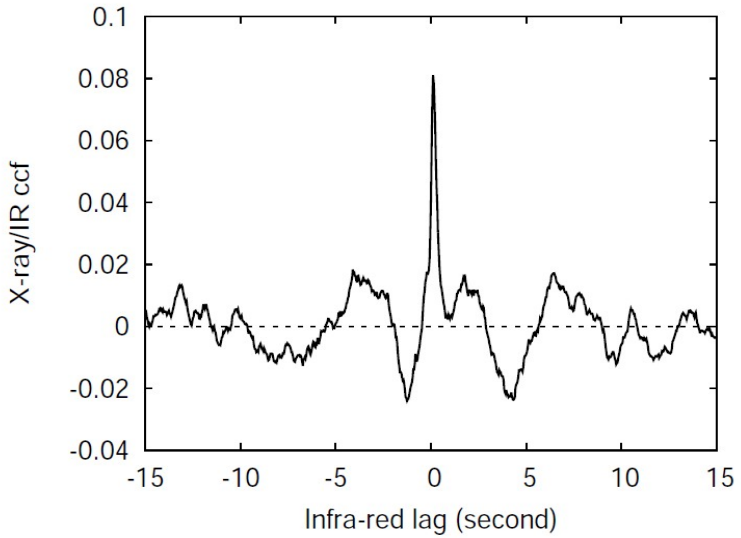


Origin of variable IR emission

- ✗ Intrinsic outer disc emission? — Variability time scales are too fast
- ✗ Reprocessing of variable X-ray emission incident on outer disc? — Too short CCF delay; Highly inclined disc and a highly asymmetric CCF required
- ✗ Synchrotron emission from outer hot flow? — Unlikely

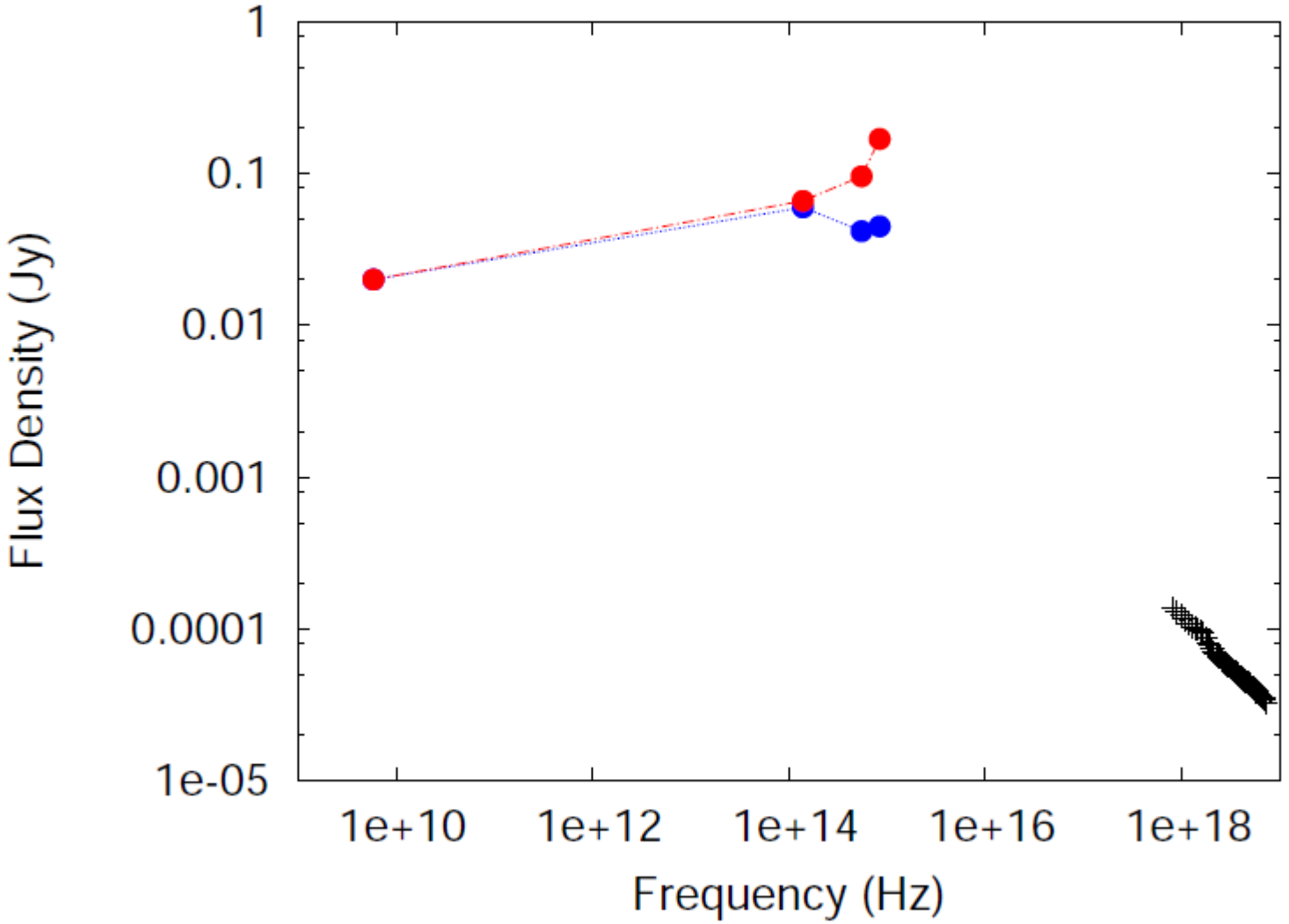
Synchrotron emission from the jet?



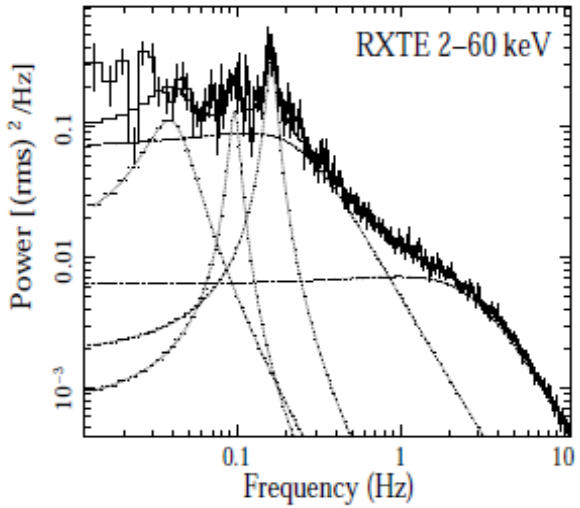


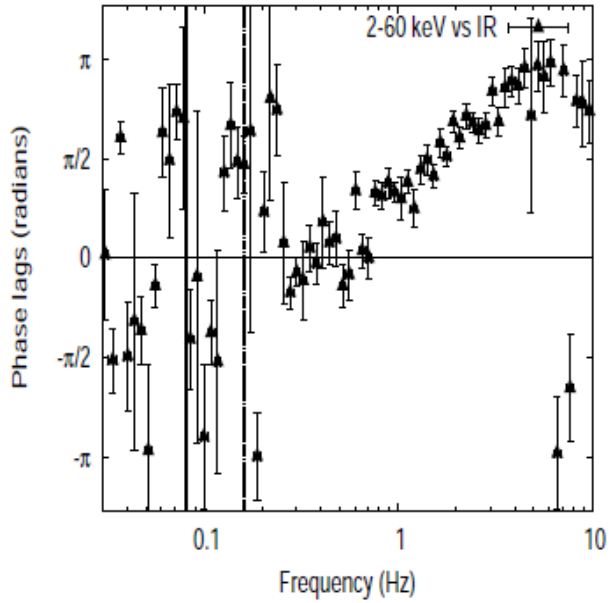
Origin of variable IR emission

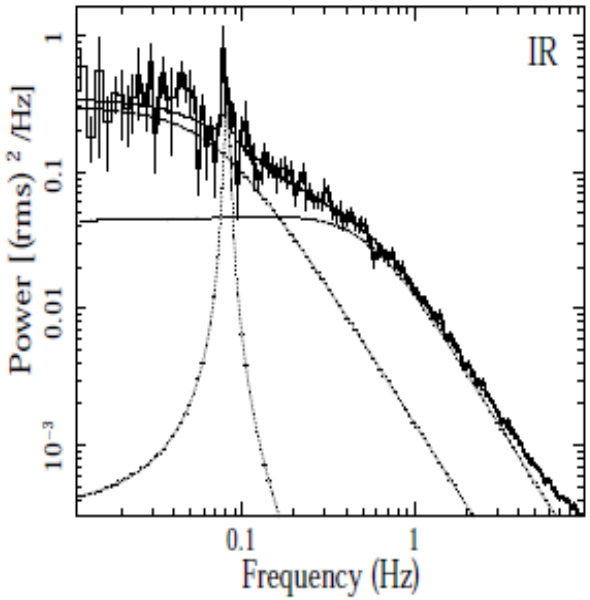
Synchrotron emission from the jet?

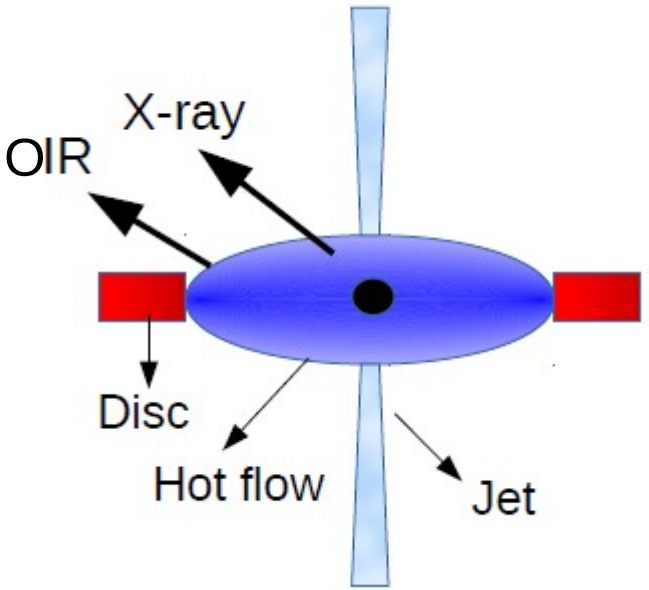


Origin of the IR QPO









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