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
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 (543 nm)  
   2.3 eV

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

Hardness- Intensity Diagram
Power density spectra

RXTE 2–60 keV

XMM 0.3–2 keV
Power density spectra

RXTE 2-60 keV

0.161 +/- 0.003 Hz

XMM 0.3-2 keV

0.164 +/- 0.003 Hz

IR

0.080 +/- 0.001 Hz
Power density spectra

RXTE 2–60 keV
0.161 +/- 0.003 Hz

XMM 0.3–2 keV
0.164 +/- 0.003 Hz

IR
0.080 +/- 0.001 Hz

OM U band
0.082 +/- 0.002 Hz

OM V band
0.082 +/- 0.002 Hz
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?

![Diagram showing X-ray and IR emission from a disc and jet](image)
Origin of variable IR emission

- **X** Intrinsic outer disc emission?
  - Variability time scales are too fast

- **X** 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