Eavesdropping on accretion disks: Broad-band variability properties of cataclysmic variables and their connections to XRBs/AGN

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Overview

- Why look at CVs?
- The first timing connection: the rms-flux relation
- QPO evolution in CVs
- Coherence and Fourier time-lags in CVs
- Future work / Making sense?
Why look at CVs?

- Observationally both XRBs and CVs exhibit large-amplitude outbursts
- Theoretically explained through thermal/viscous instabilities in the accretion disks (Shakura & Sunyaev 1973)
- Radio emission/jets observed in conjunction with spectral changes (Koerding et al. 2008)
- Accretion disk dynamics governed by the embedded gravitational potential

CVs offer a unique laboratory to study accretion in the absence of strong gravity and strong X-ray emission!
Why look at CVs?  
(with Kepler)

32 CCDs → 95 Megapixels!
Why look at CVs?
(with Kepler)

100 square degree field-of-view
MV Lyrae with Kepler

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Accretion2013
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MV Lyrae with Kepler

(Scaringi et al. 2012a)
QPOs in MV Lyrae

- Dynamic PSD → 5.3 day segments with 50% overlap

(Scaringi et al. 2012b)
QPOs in MV Lyrae

Average of 5 independent PSDs
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QPOs in MV Lyrae
QPOs in MV Lyrae

\[ V_{\text{max},3} \left( 10^{-4} \text{ Hz} \right) \]

vs.

Mean flux \( \left( 10^4 \text{ e}^- \text{ s}^-1 \right) \)

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QPOs in MV Lyr

- Highest frequency Lorentzian:
  - varies between 5%-10%
  - Use this to constrain the minimum size of the emitting region

(Scaringi et al. 2012b)
Viscous or dynamical?

\[ \nu_{\text{dyn}}(r) = \frac{1}{t_{\text{dyn}}(r)} = \sqrt{\frac{GM}{r^3 4\pi^2}}, \]

- High frequency break
  → Accretion disk truncates at \( \sim 10R_{\text{WD}} \)
- Lowest frequency Lorentzian
  → Outer disk edge is beyond L1 point

\[ \nu_{\text{visc}}(r) = \alpha \left( \frac{H}{R} \right)^2 \nu_{\text{dyn}}(r), \]

- Both high and low frequency components
  → Large \( \alpha > 0.1 \)
  → Large \( H/R > 0.3 \)
Coherence and Fourier time lags in MV Lyr and LU Cam

- ULTRACAM observations on the 4.2 m WHT with simultaneous $u', g', r'$
- MV Lyr $\rightarrow 12h, \sim 0.8s$ cadence
- LU Cam $\rightarrow 6h, \sim 1.3s$ cadence
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Coherence and Fourier time lags in CVs

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(Scaringi et al. 2013)
Coherence and Fourier time lags in CVs

- **Soft-lags** → **Viscous propagation**
- Disk reprocessing from boundary layer photons/“corona”/?

<table>
<thead>
<tr>
<th><strong>AGN - XRBs</strong></th>
<th><strong>CVs</strong></th>
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</thead>
<tbody>
<tr>
<td>High-energy photons photoionising disk surface layers</td>
<td>UV photons heating disk surface layers</td>
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<tr>
<td>→ Soft-lags observed as “reflection” from different disk radii (Fabian et al. 2009, De Marco et al. 2013)</td>
<td>→ Disk reprocesses photons and re-emits them on the thermal timescale</td>
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<tr>
<td>→ Lags interpreted as light-crossing time from central object to disk</td>
<td>→ Lags interpreted as thermal timescale at specific disk radius?</td>
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Future work...

- Look at Fourier-dependent time-lags in Dwarf Nova (SS Cyg?)
  → Will the more “standard” CVs show hard-lags?
- Broad-band variability comparison of a population of CVs to XRBs/AGN
  → Known Kepler CVs ~40, and more to be found! (maybe an XRB as well?)
- AGNs with Kepler! (~400 in the FOV)
- Making sense of all of it!
Spectral/timing properties of accreting objects: from X-ray binaries to AGN CVs

ESA/ESAC, Madrid, Spain, April 3-5, 2013


Topics

- Accretion modes at different scales
- States and state transitions
- Inflow/outflow connections
- Accretion/ejection mechanisms
- Unification schemes

Thanks!
Kepler-INT Survey (KIS) (U, g, r, i, Ha)

Blue excess sources + H-alpha excess sources + WISE colours

(Scaringi et al. 2012c)
MV Lyrae

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(Scaringi et al. 2012a)
• The obtained rms-flux relations are remarkably similar between BH accretors (X-rays) and WD accretors (optical)
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