X-ray / optical correlations
in the transient black hole system
KV UMa (J1118+48)

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The year 2000 transient: XTE J1118+48 (=KV UMa)

- nearby object (~ 2 kpc) at high galactic latitude
- estimated mass of compact star > 6 $M_\odot$
- Hard spectral state with high variability
- high optical / X-ray luminosity ratio

Correlated observations using a RXTE-PCA ToO program and OPTIMA from Skinakas observatory, Crete were carried out during July 4-8, 2000
A total of 2.5 hours of coincident measurements were performed!

(Kanbach, Straubmeier, Spruit, and Belloni, 2001, Nature 414, 180)
**Optical-EUV-X-ray spectrum**

**Data from April 18, 2000**

**EUVE data from April 16, 2000**

**High optical / X-ray luminosity ratio!**

\[ L_{\text{opt-EUV}} \sim 10^{36} \text{ erg s}^{-1} > L_X \Rightarrow \text{variable optical radiation can not be reprocessed X-rays} \]

- Synchrotron emission?
  - steep turn-over of spectrum at EUV is hard to explain with non-thermal synchrotron emission
  - a thermal cyclo-synchrotron emission is more likely with \( T_e \sim 200 \text{ keV}, B \sim 10^6 \text{ G}, \) optical thickness up to ~ 100

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**XTE J1118+48 (KV UMa)**


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RXTE and OPTIMA Lightcurves

Jul 4, 12

RXTE Rate (cts/60ms)

0 10 20 30 40 50

KV UMa

OPTIMA Rate (cts/60ms)

0 1100 1200 1300 1400 1500 1600

KV UMa

Mean X-Ray and Optical „Flares“ (~100)

KV UMa

RXTE

OPTIMA
`Reprocessing` or `Light-Echoes`

- Reprocessing
- Light-Echoes

- X-ray pulse
- Optical pulse delayed
- Preceding
- X-opt correlation
- Heating
- Shadowing?

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Positive correlation with short rise (~ 100ms)
Maximum at ~ 500 ms; length ~ 5 sec;
onset of sharp rise within 30 ms of
X-ray peak;

Anti-correlation at -2 sec: 'precognition dip'
Autocorrelation Functions

Time scales of the optical emission are much shorter than at X-rays. This is inconsistent with a reprocessing scheme!
Emission Models: The brightness temperature and the SED indicate that self-absorbed cyclo-synchrotron emission causes the optical signal. The size of the emitting region is < 30,000 km.

A "quasi spherical" slow outflow crossing photospheric surfaces:
- EUV @ $10^7$ - $10^8$ G
- Optical @ $10^6$ G, r=20000 km

X-ray and radio emission blobs:
- Fast jet: $\beta \sim 0.5-0.9$
- Slow outflow: $v < 30000$ km/s
  - Optical emission @ d~ 20000 km

A "jet-like" slow outflow:

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New Analysis

Principal Components Analysis
(Spruit & Kanbach A&A 391, 225-233, 2002)

Analysis of 250 events +/- 100 s results in 2 independent components:

- Shot Analysis

  - analysis of different (RXTE) X-ray spectral bands
    - events similar in all spectral bands and correlated with optical;
      anticorrelation of X-ray flux and hardnes ratio
  - separate analysis of strong and weak events (shots)
    - events similar

  Conclusion:
  one emission process that creates X-ray and optical emission.
  Similar structure on different time scales.

no time-of-flight effect?
both dip and peak are properties of optical light
Optical emission from slow outflow

[Graph showing cross-correlation between X-rays and optical emission]

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The OPTIMA photometer

APD: high Q.E. ~60% (450-950 nm)

Timing with GPS ~ 2 µs

Standby Mode

OPTIMA @ 1.3m Skinakas
Origin of Optical-EUV spectrum
(continuum with weak lines)

$L_{\text{opt-EUV}} \sim 10^{36} \text{ erg s}^{-1} > L_X \Rightarrow$ variable optical radiation can not be reprocessed X-rays

Synchrotron emission?

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![Graph showing log $F_\nu$ vs log $\nu$ with thick and thin lines for therm CS and non-thermal synch with $-(p-1)/2$ and slope $5/2$.]