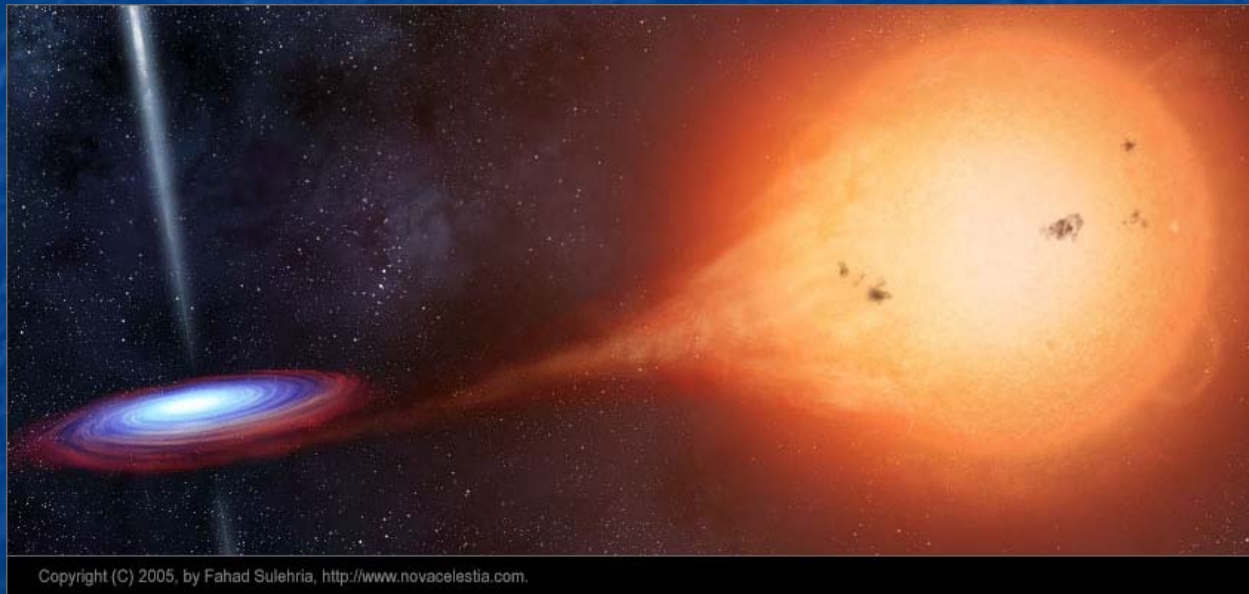


# IR Activity of the X-ray Binary GX 17+2: Possible Periodicity

Jillian Bornak<sup>1</sup>

Tom Harrison<sup>1</sup>, Bernie McNamara<sup>1</sup>, Michael Rupen<sup>2</sup>,  
Reba Bandyopadhyay<sup>3</sup>, Stephanie Wachter<sup>4</sup>



<sup>1</sup> New Mexico State University

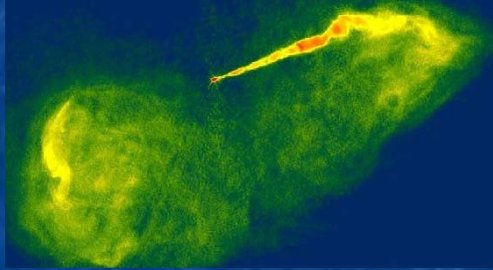
<sup>2</sup> National Radio Astronomy Observatory

<sup>3</sup> University of Florida

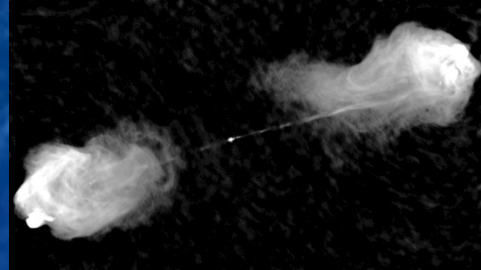
<sup>4</sup> *Spitzer* Space Center

NM Space Grant  
10/31/2008

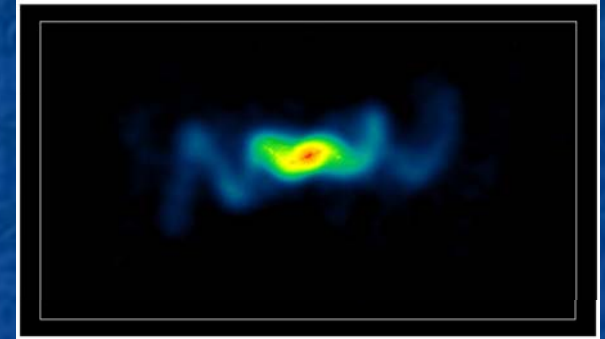
# Jets in Astronomy



[http://www.star.le.ac.uk/~sav2/blackholes/quasars/m87\\_vla.jpg](http://www.star.le.ac.uk/~sav2/blackholes/quasars/m87_vla.jpg)



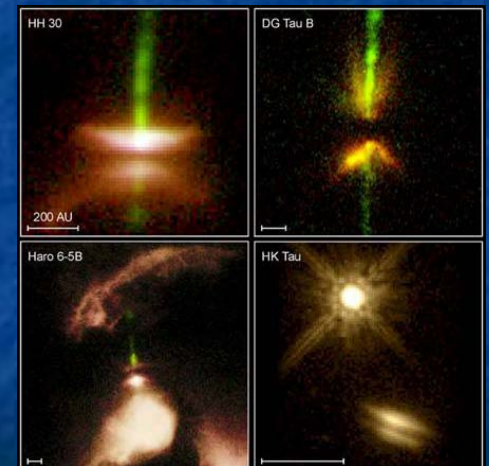
<https://eee.uci.edu/clients/bjbecker/ExploringtheCosmos/>



<http://www.nrao.edu/pr/2004/ss433corkscrew/>

- SMBHs
  - Blazars, Seyferts, AGN
- Stellar binaries
  - X-ray binaries, cataclysmic variables, novae
- Protostars
  - T Tauri, Herbig-Haro objects

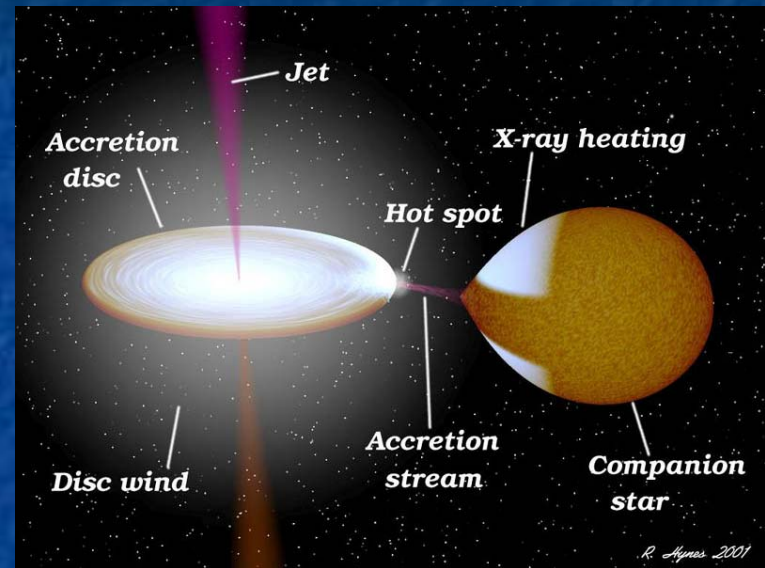
... Where we find accretion, we find jets



<http://astronomyonline.org/Exoplanets/images/Exoplanets/>

# Introduction to X-ray Binaries

- Bright X-ray sources
- Accreting compact object
- Low Mass X-ray Binaries (Roche Lobe overflow)  
vs.  
High Mass X-ray Binaries (wind accretion)
- Multiple possible emission components
  - radio: jet and ejected plasma bubbles
  - OIR: accretion disk, secondary star, jet
  - X-ray: accretion disk, accretion disk corona, jet

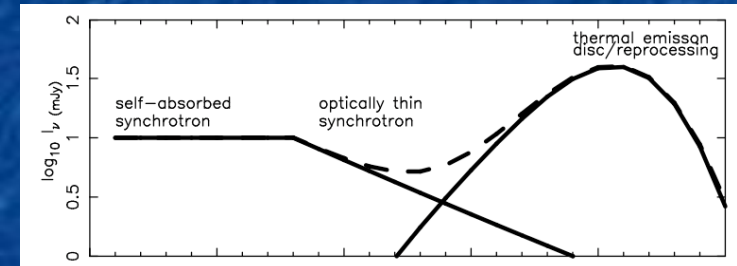


<http://www.redorbit.com>

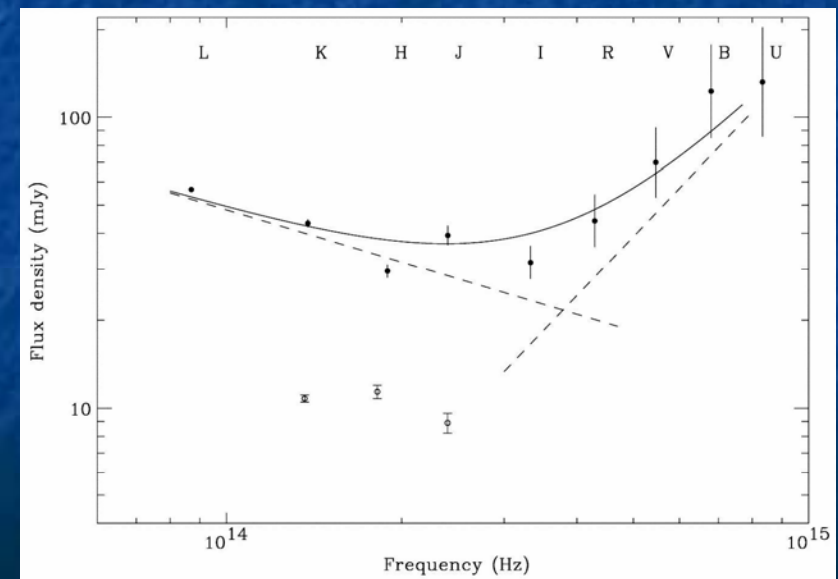
*R. Hayes 2001*

# Black Holes and Jets

- Synchrotron radiation
  - characteristic break
  - jet should be strongest in radio, IR, high energy X-rays
- Low/hard state
  - synchrotron spectra  
XTE J1118+480, Cyg X-1
  - radio/X-ray correlation  
V404 Cyg, GRS 1915+105
- No direct observation of break
  - Corbel & Fender (2002) GX 339-4
- Resolved radio jets
  - Cyg X-1, GRS 1915+105 (radio/IR)



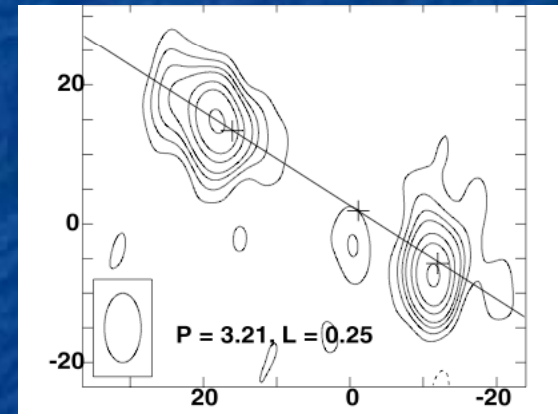
Shahbaz et al. 2008



Corbel and Fender (2002)

# Neutron Stars and Jets

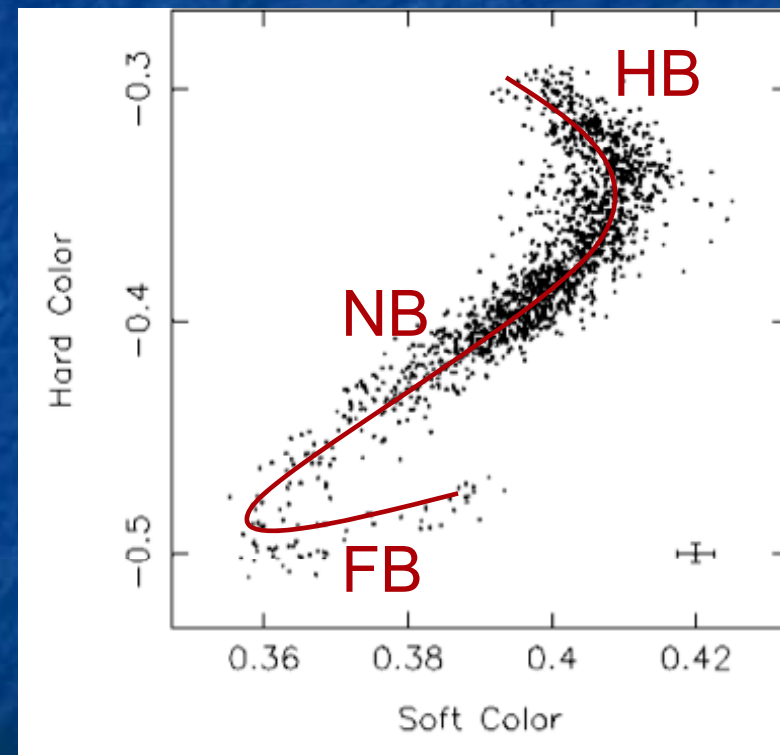
- Black holes & neutron stars
  - association of bright X-ray outbursts and radio flares
  - states with high energy X-rays, strong variability, radio emission
  - large-scale radio lobes in surrounding gas
- Sco X-1, Cyg X-2
  - intrinsic linear IR polarization
  - radio/X-ray coupling
- 4U 0614+091
  - mid-IR synchrotron emission
  - indicates break with wavelength  $> 8 \mu\text{m}$
- Synchrotron jets proposed to explain IR excess of ms pulsars



Fomalont et al. (2001)

# Z Source X-ray Binaries

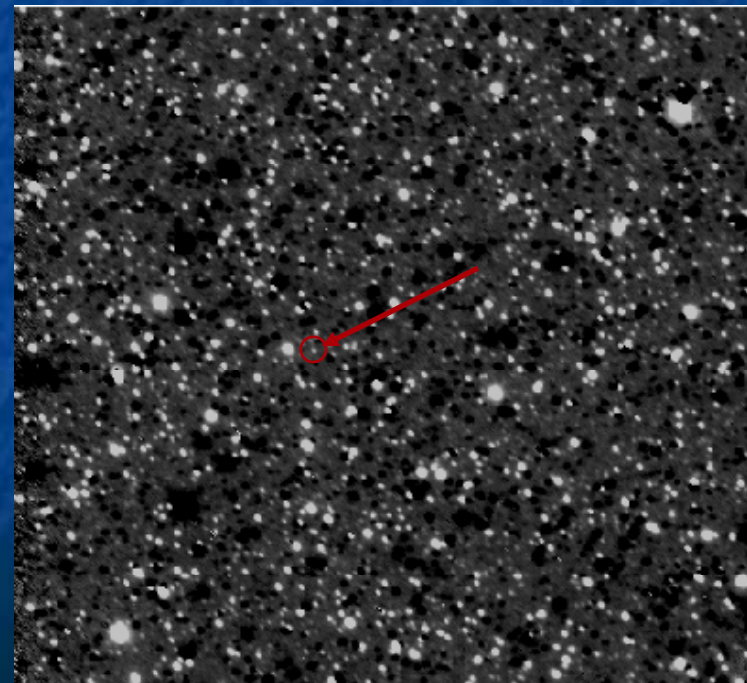
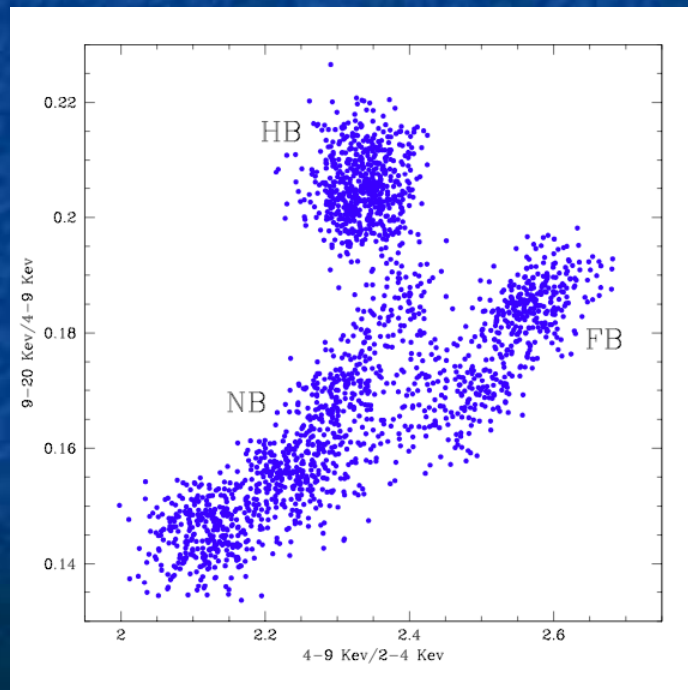
- Only eight known sources:  
Cyg X-2, GX 5-1, GX 340+0,  
XTE J1701-462, Sco X-1,  
GX 17+2, GX 349+2, LMC X-2
- X-ray color-color diagram:  
horizontal, normal, flaring  
branches
- HB/NB similar state to black  
holes' low/hard state
  - increased radio activity
  - high energy X-ray tail



Wijnands et al. 1998

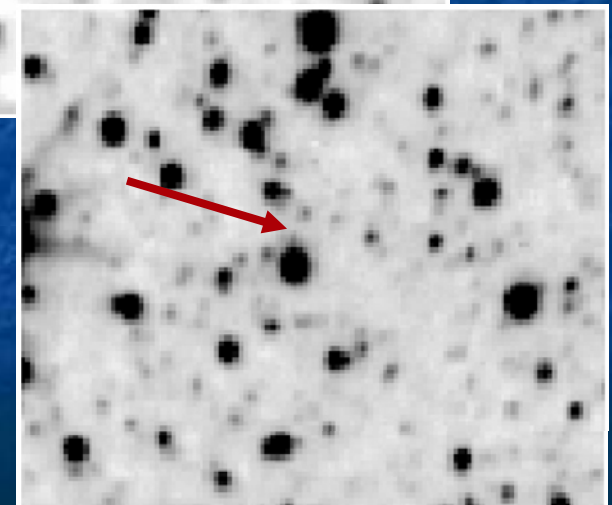
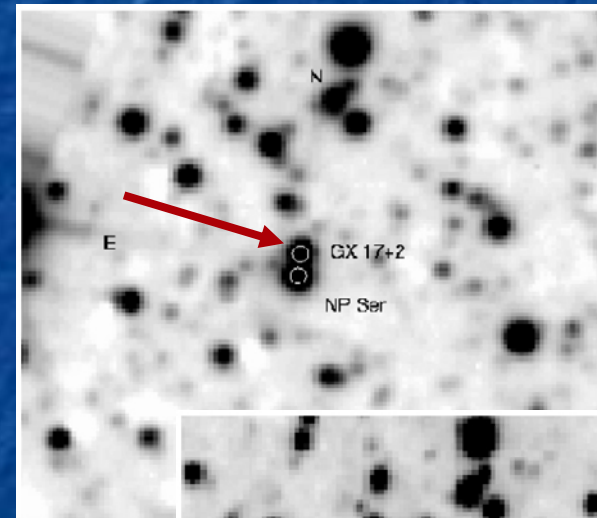
# Z Source GX 17+2

- One of the brighter Z sources
- $\sim 10$  mJy radio source
- Radio/X-ray correlation
- Heavily obscured ( $A_V \sim 19!$ ), distance estimate 8 kpc



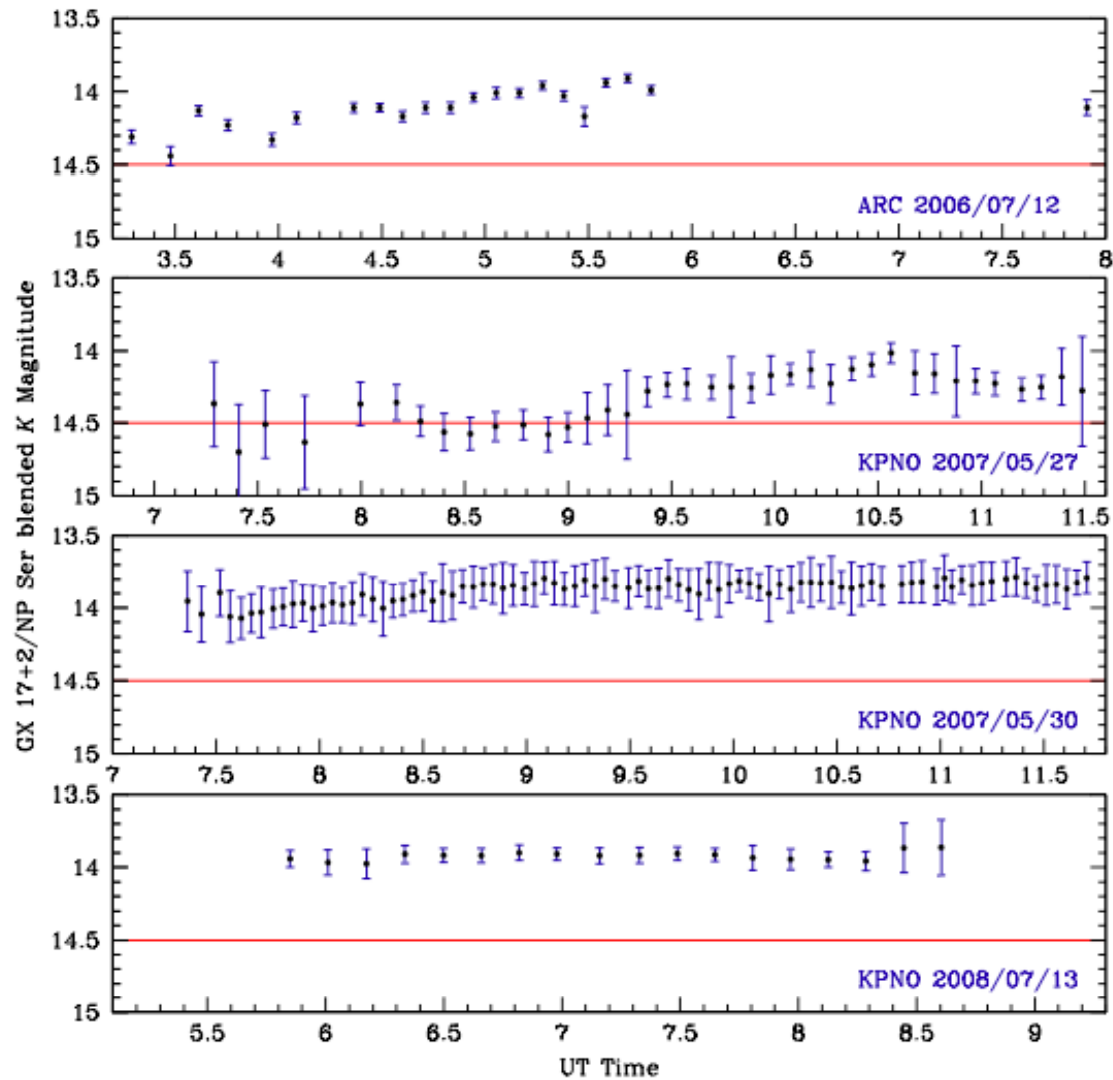
# Struggle for the Optical/IR Counterpart: 1972-2002

- X-ray and radio position indicated a star then named NP Ser ...  
... but it had the spectrum of a boring G star!
- Keck observations resolved GX 17+2 from the field G star
  - unexpected  $\Delta K \sim 3.5$  mag



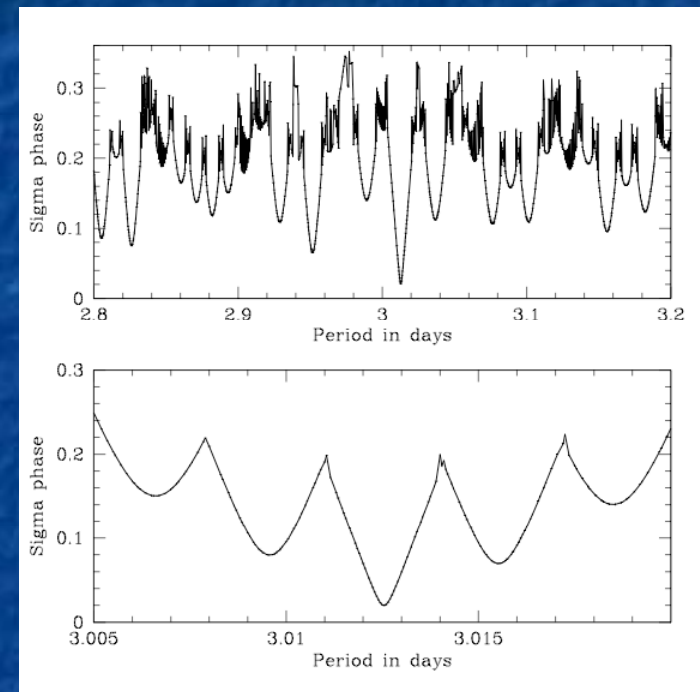
Callanan et al. 2002

# K Band Light Curves



# IR Behavior

- Five IR bright observations
- Numerous non-IR bright observations
- Phased dates over a range of periods, searched for least dispersion in phase
- Added Callanan et al. (2002) observation
  - ephemeris covers 1999-2008

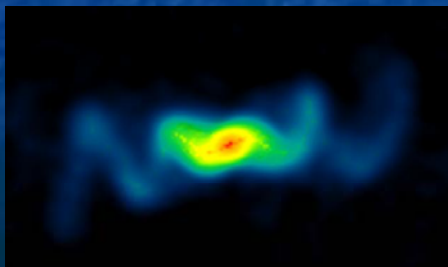


$$P = 3.012 \text{ d}$$

# Source of IR Emission

- EXOSAT, Ginga, and RXTE X-ray databases
  - no eclipses, no dipping, no corresponding X-ray periodicity
- IR not from a disk brightening event, free-free from accretion disk wind, or heating of donor star
- Not flare event from donor star
  
- Need spectral index confirmation to clinch synchrotron
- What causes the periodicity?

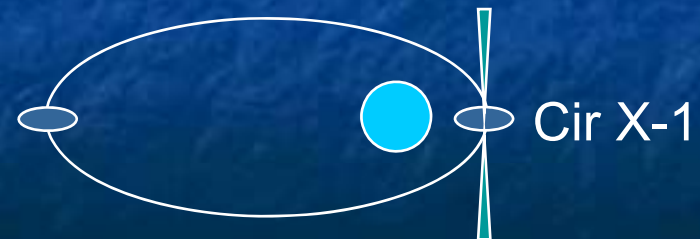
- precessing jet?



SS 433

Blundell & Bowler, NRAO/AUI/NSF

- eccentric binary?



Cir X-1

# Future Work

Closing in on GX 17+2's compact jet ...

- Simultaneous radio/OIR/X-ray coverage of GX 17+2 and six other systems
  - RXTE ASM public data (X-rays)
  - RXTE PCA request director's (X-rays)
  - NMSU 1m guaranteed (optical)
  - IRTF proposal submitted (IR)
  - VLA proposal will be submitted (radio)
- Full IR light curve rise-peak-fall
- Spectral index, break, jet opening angle, total jet power
- Radio/X-ray correlations, radio/IR correlated oscillations
- High-speed IR photometry places upper limits on physical size of emission region



<http://www.space-art.co.uk>