XTE J1906+090: From Serendipity Towards a Be/X-ray Binary

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This is a `neutron star' talk..

Following the lines of the education reform, I will try to achieve

'No Scientist Left Behind'

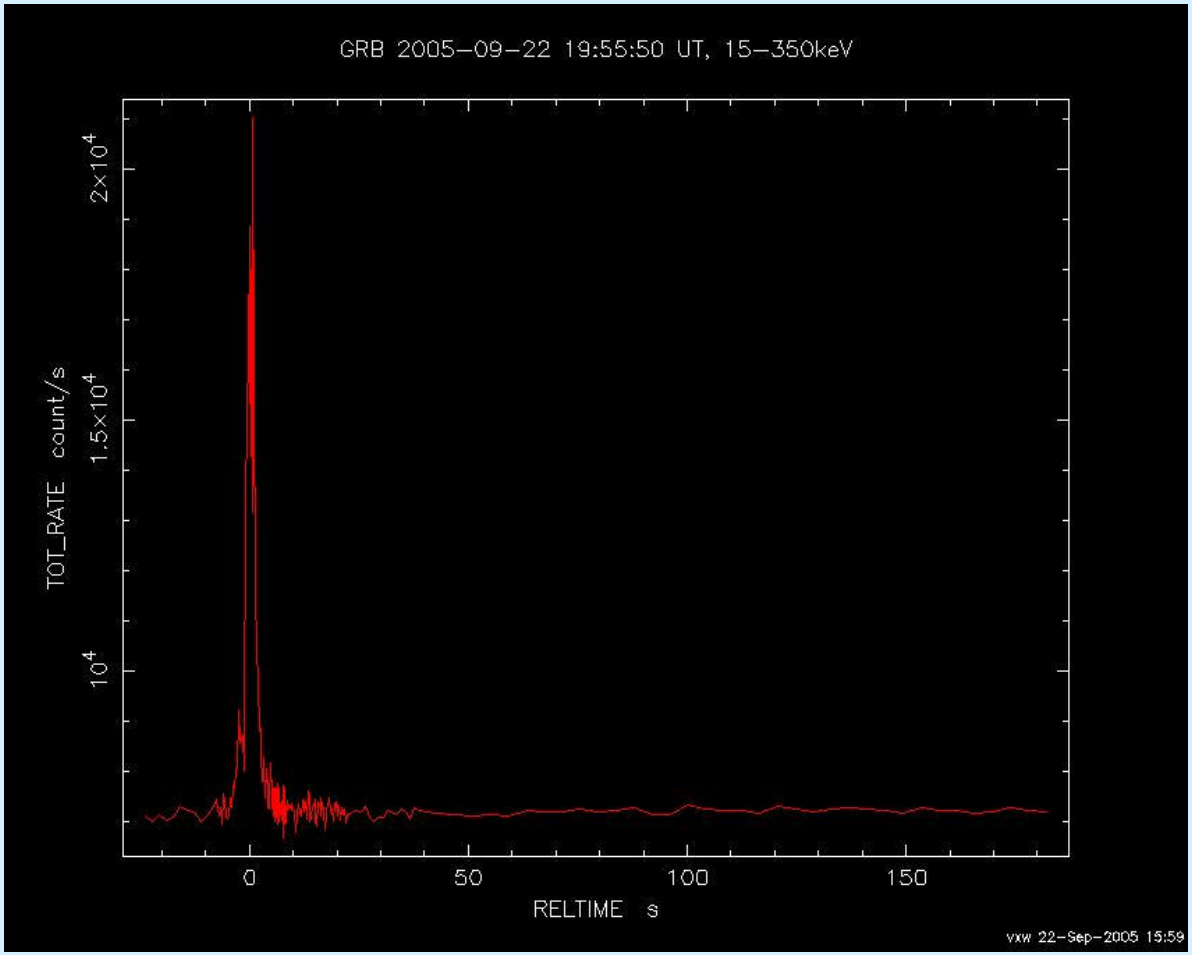
March 29, 2006

"International Meeting During The Total Solar Eclipse 2006“

A great possibility to attend a meeting while prepare for observations and experiments and to do it right on the spot, on the line of totality.

http://eclipse2006-conf.ankara.edu.tr/prog.php

GRB 050922C

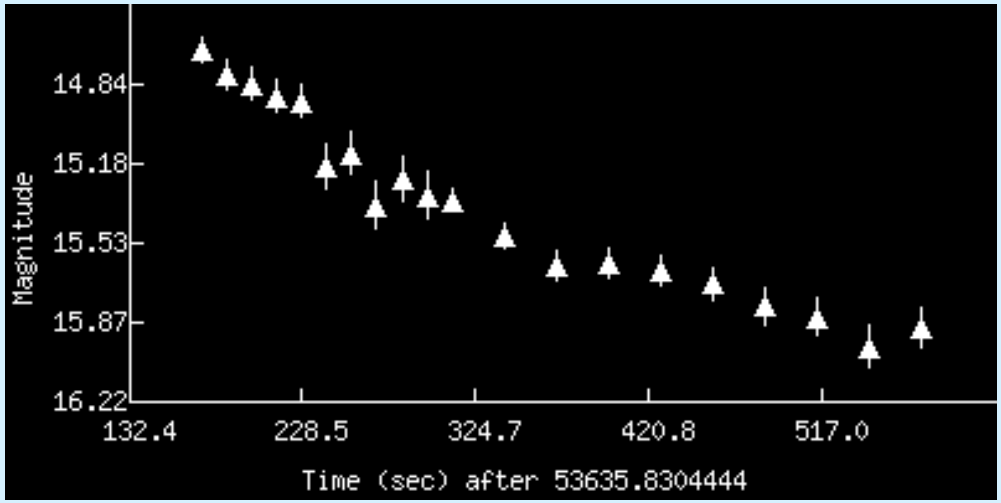


Detected with Swift, HETE-II

5th GRB detected with orbiting satellites

z = 2.17

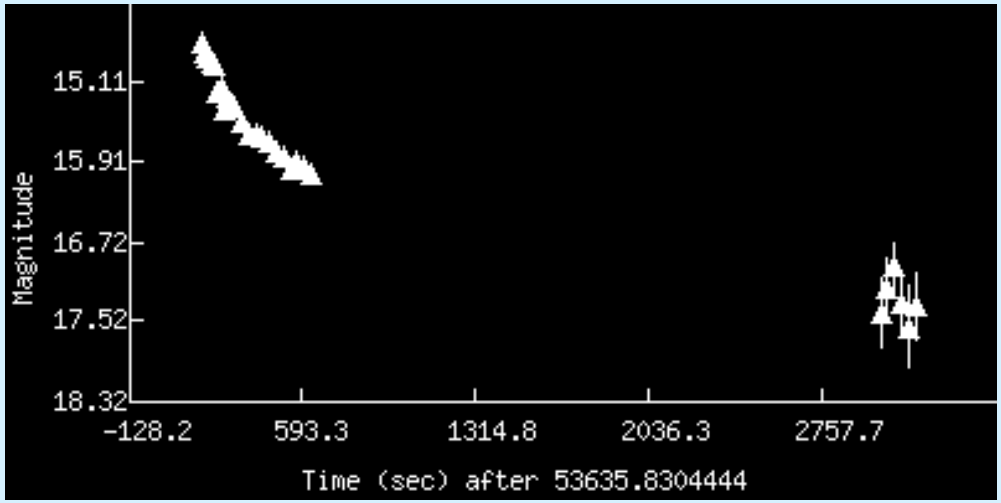
ROTSE IIID Light Curve



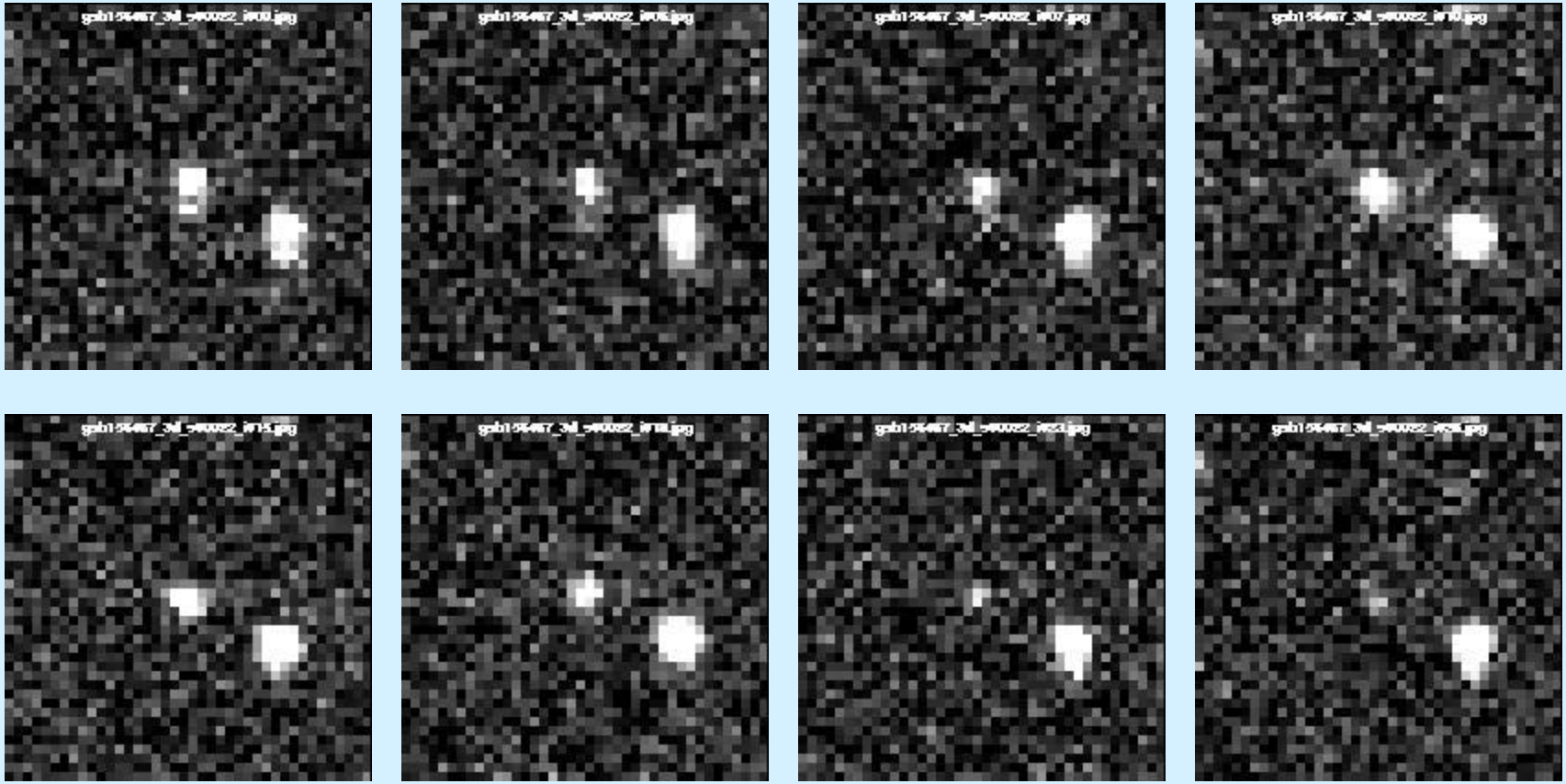
Started observations at T_{burst}+172.4 s (T_{GCN}+6.8 s)

Interrupted at ~651 s due to precipitation

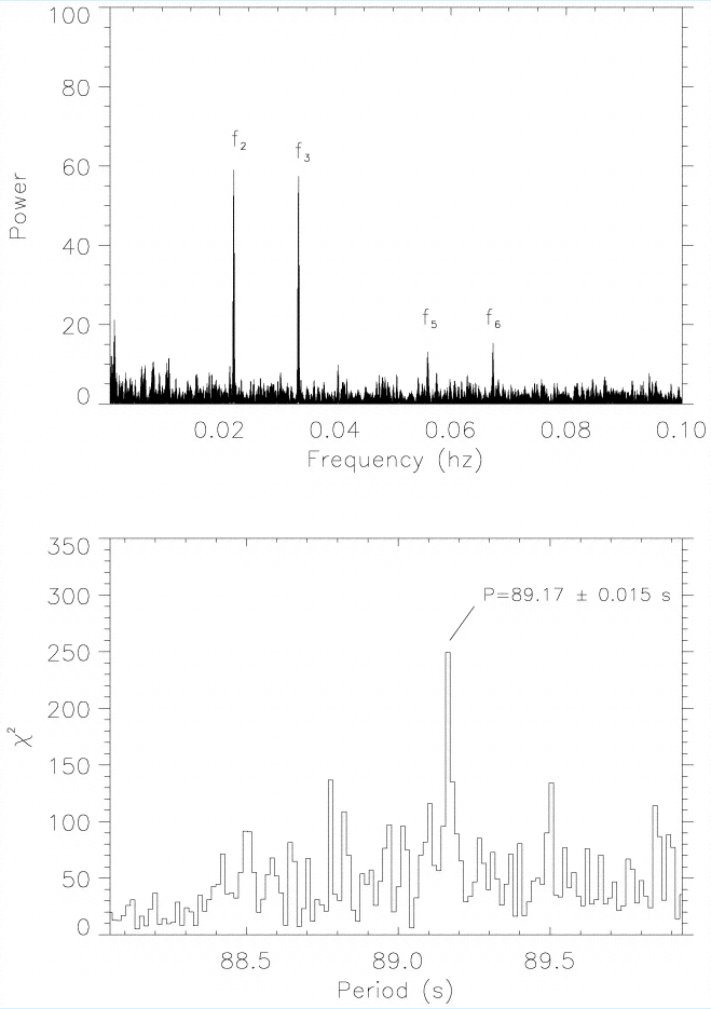
Power law decay index is ~ –1



ROTSE IIID Observations of GRB 050922C



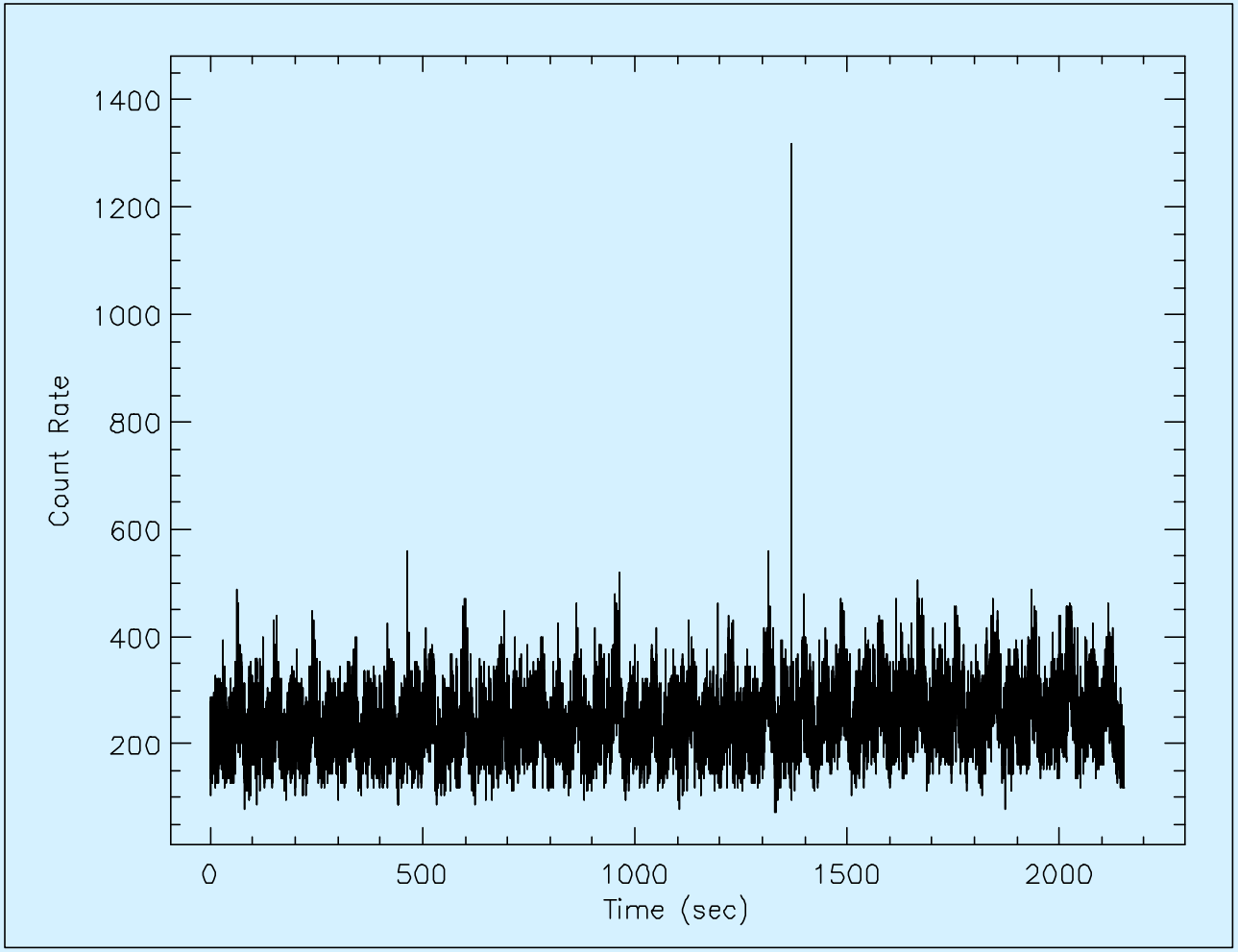
XTE J1906+090



- Discovered in 1998 based on RXTE observations of the field of SGR 1900+14 in September 1996
- P_{spin} ~ 89 s
- Hard X-ray spectrum is harder than HMXBs
- Based on P_{spin} and L; associated with a double M super-giant binary system? → the first known triple X-ray system!

(Marsden et al. 1998)

two years later…



Another active episode in September 1998

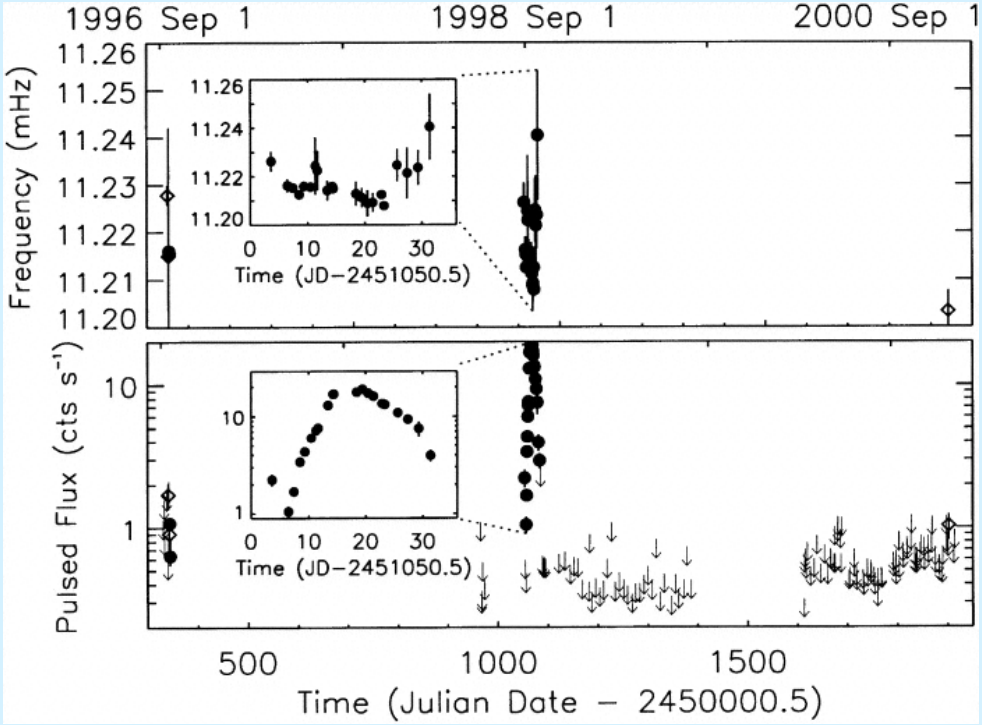
Localization with the RXTE scanning observations

RA:19h05m20s
Dec: +09º02’30’’
(error: 2’)

(Takeshima & Murakami 1998)

Wilson et al. 2002

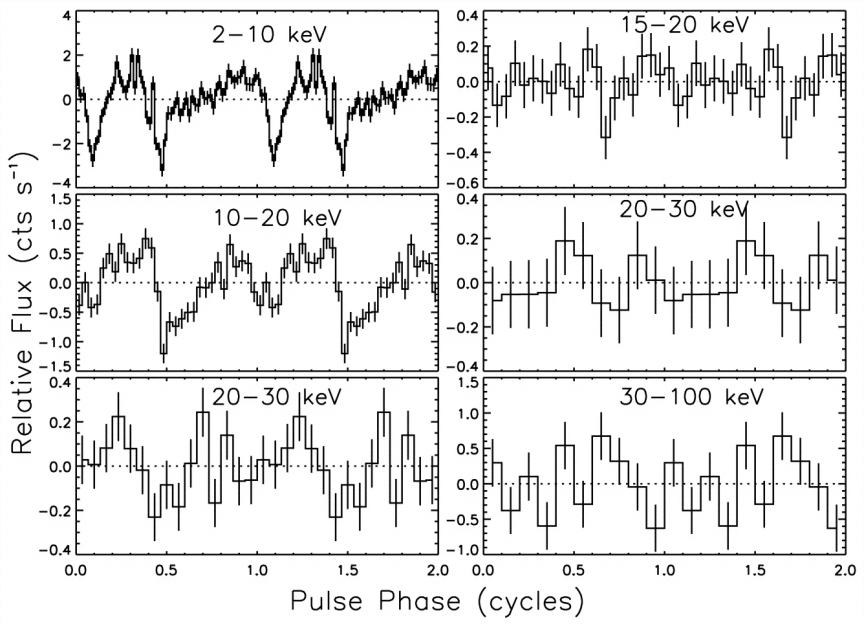
RXTE Observations: ~100 ks in Sep 1996 and ~992 ks in May 1998 – January 2001



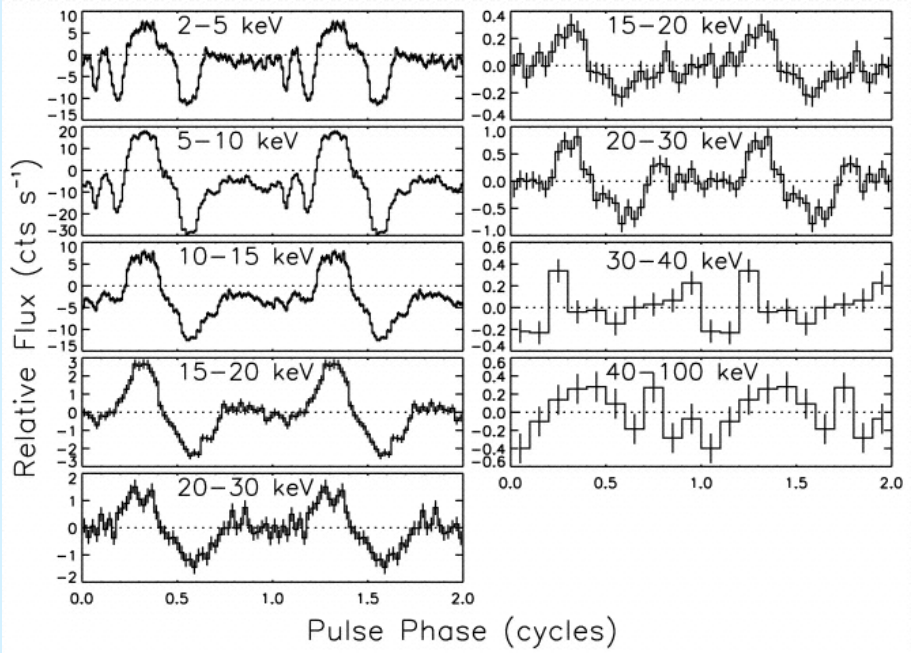
- Search for pulsations: only in Sep 1996 &1998
- F_{peak} ~$6x10^{-12}$ (cgs) in 1996 & $1.1x10^{-10}$ (cgs) in 1998
- 1998 phase-averaged spectrum shows Fe line with F~$3x10^{-12}$ (cgs)

Pulse Profiles

1996



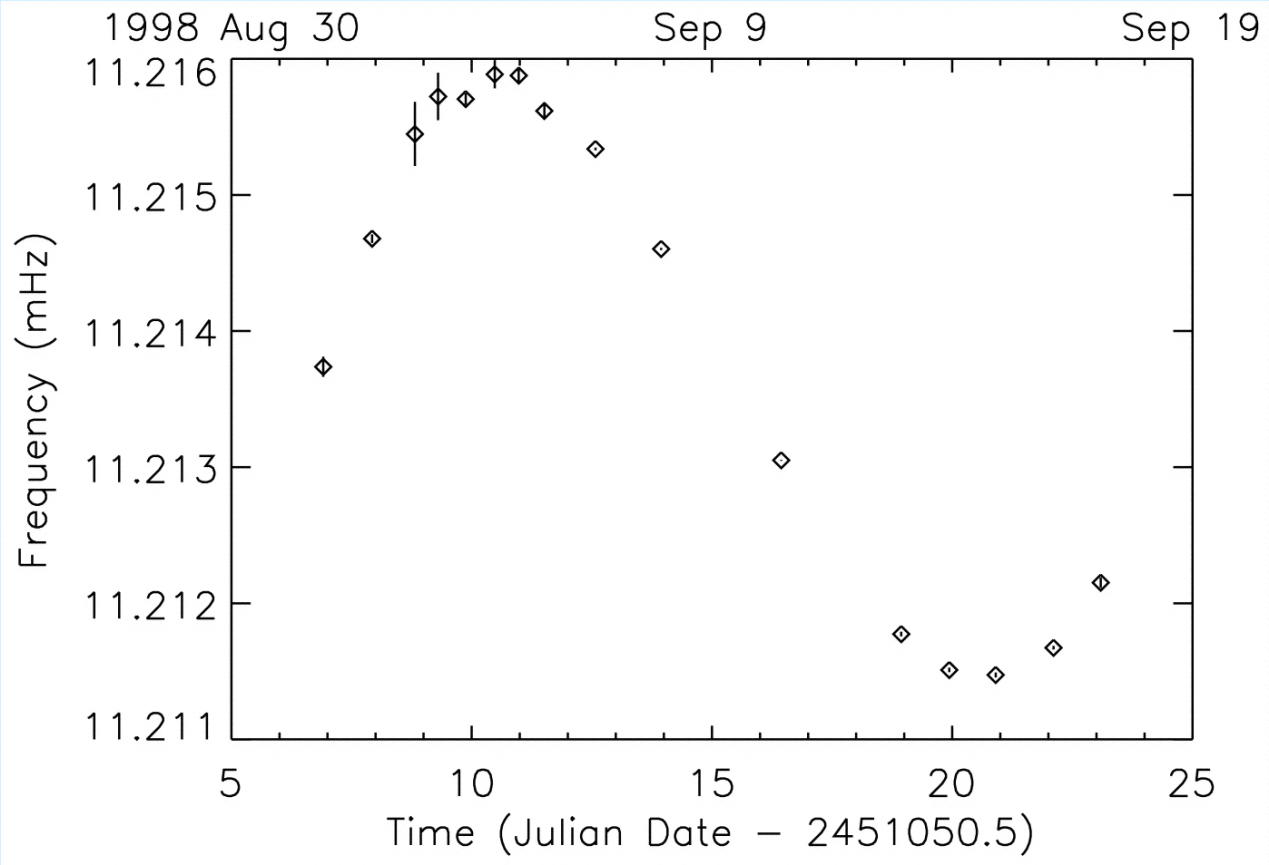
1998



(Wilson et al. 2002)

Evidence for Orbital Period

$P_{orbital} \sim 26$ d [f(M)=5 $M_\odot$] – 30 d [f(M)=20 $M_\odot$]

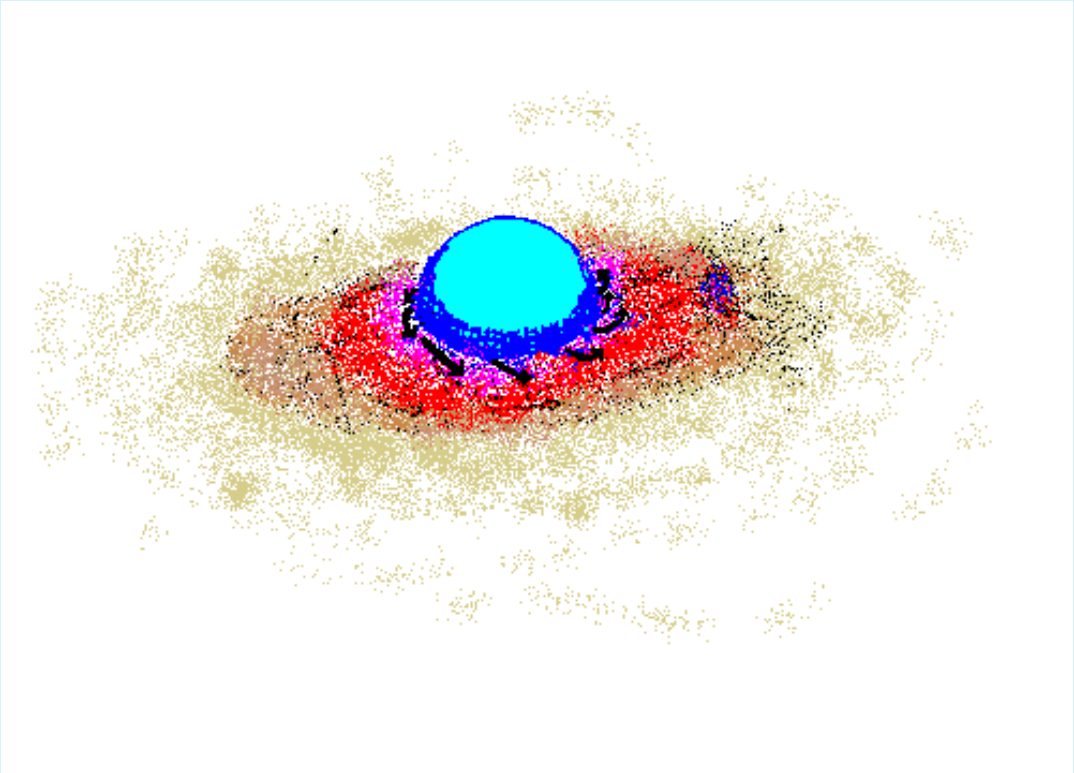


XTE J1906+090 may be in an unusual Be/X-ray binary.

(Wilson et al. 2002)

Be Stars

Be: spectral type B star that shows Balmer emission lines. They are also characterized by the excess emission of IR radiation.

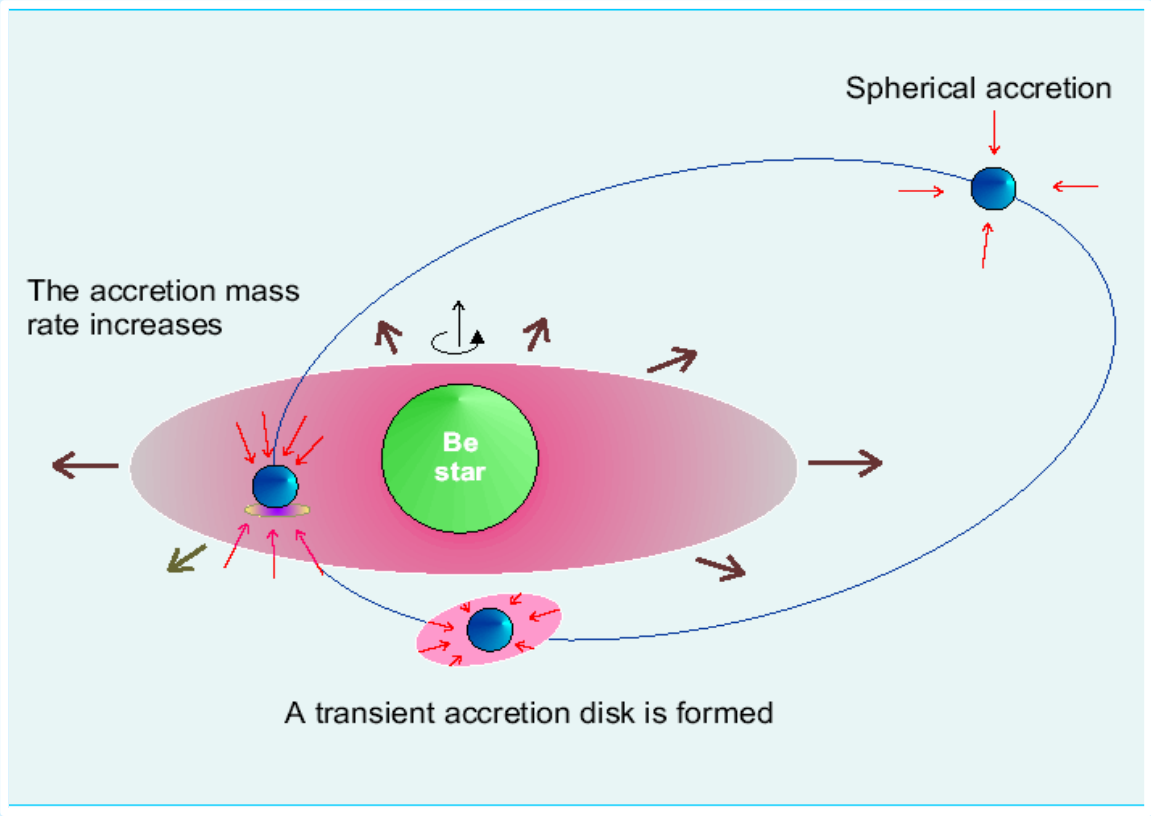


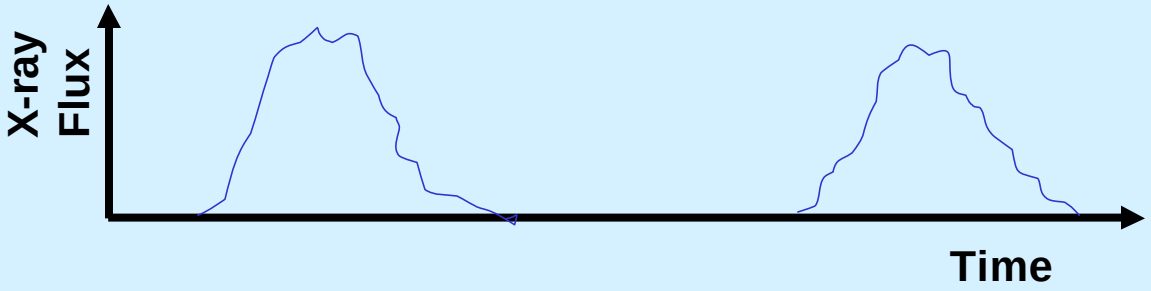
(courtesy of I. Negueruela)

Be stars rotate very rapidly, 70% of break-up speed

Material ejected forms a circumstellar disk

Be/X-ray Binaries



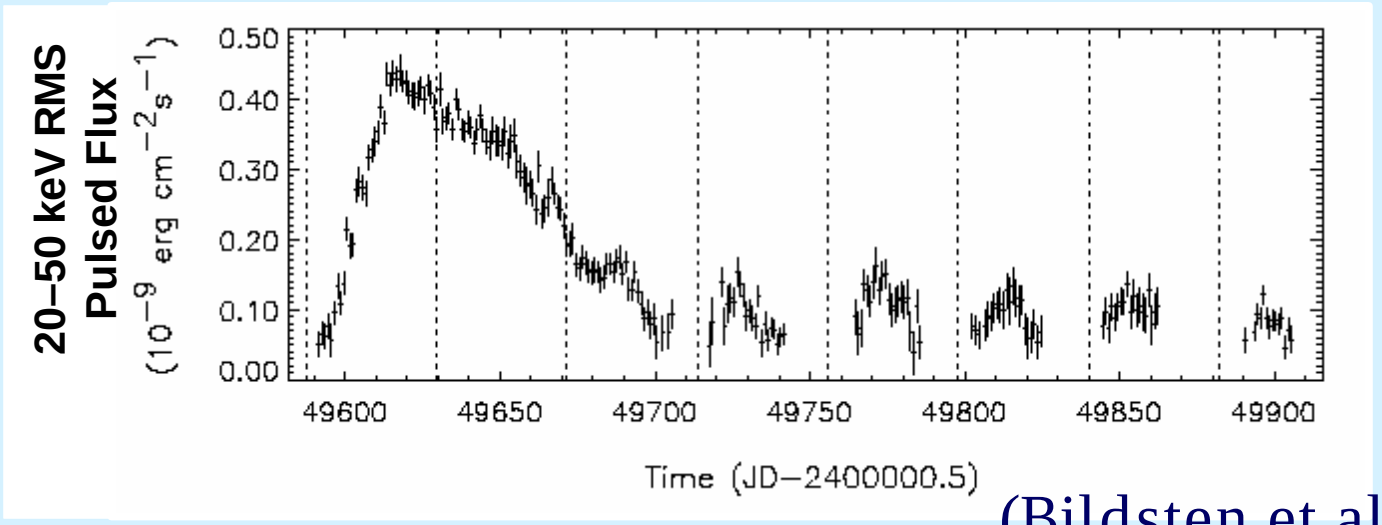


Be/X-ray Transient Outburst

- Normal (type I) outbursts: L ~ 10^{35} – 10^{37} erg/s, lasting for days to weeks, generally coincident with the time of periastron passage of the NS

- Giant (type II) outbursts: L >~10^{38} erg/s, lasting for weeks to months

2S 1417-629

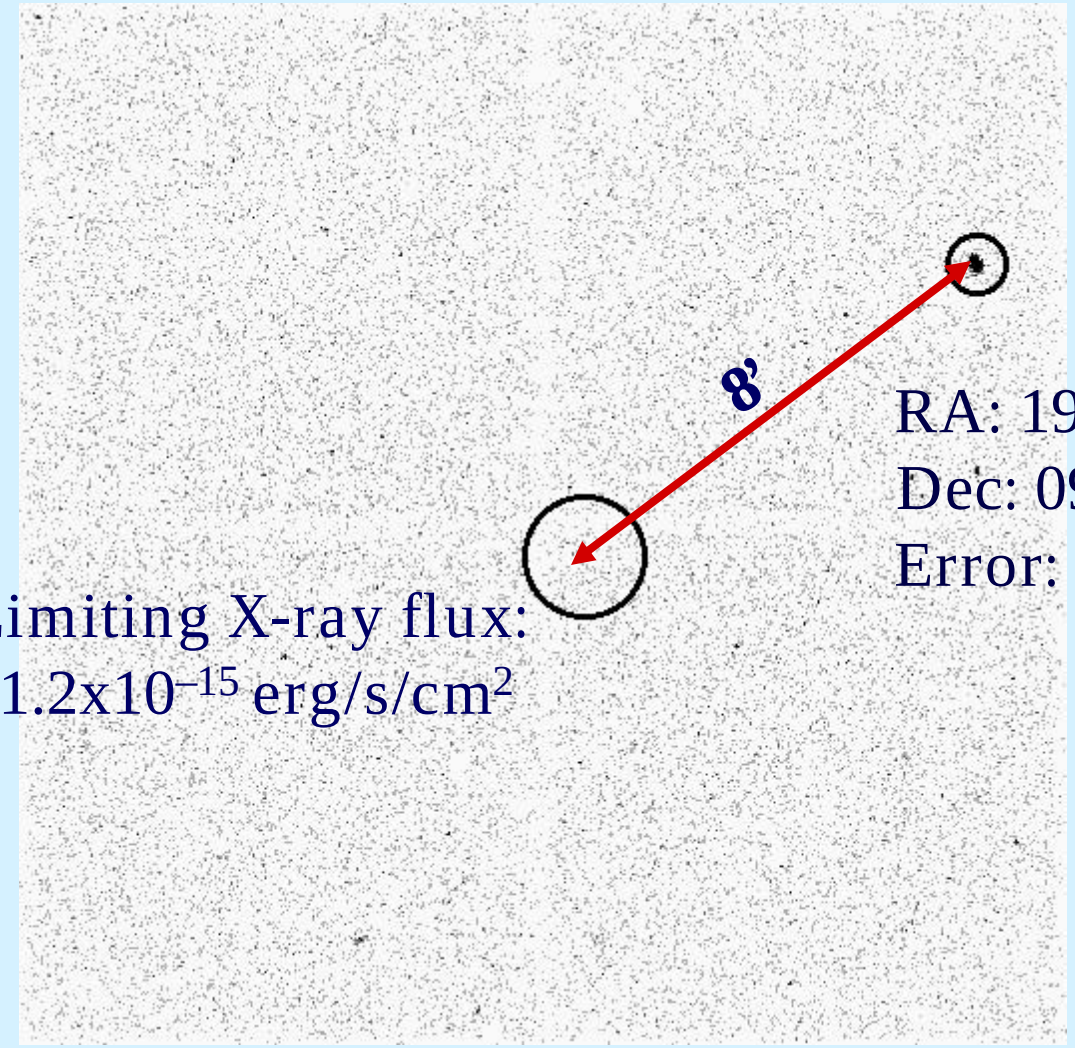


(Bildsten et al. 1997)

Chandra Observations

- Observed with ACIS–I on May 26, 2003 for 13.4 ks
- Purpose of this observation was to identify the point X-ray source
- ACIS–I aim point was set to the best known position obtained with the PCA scanning observations

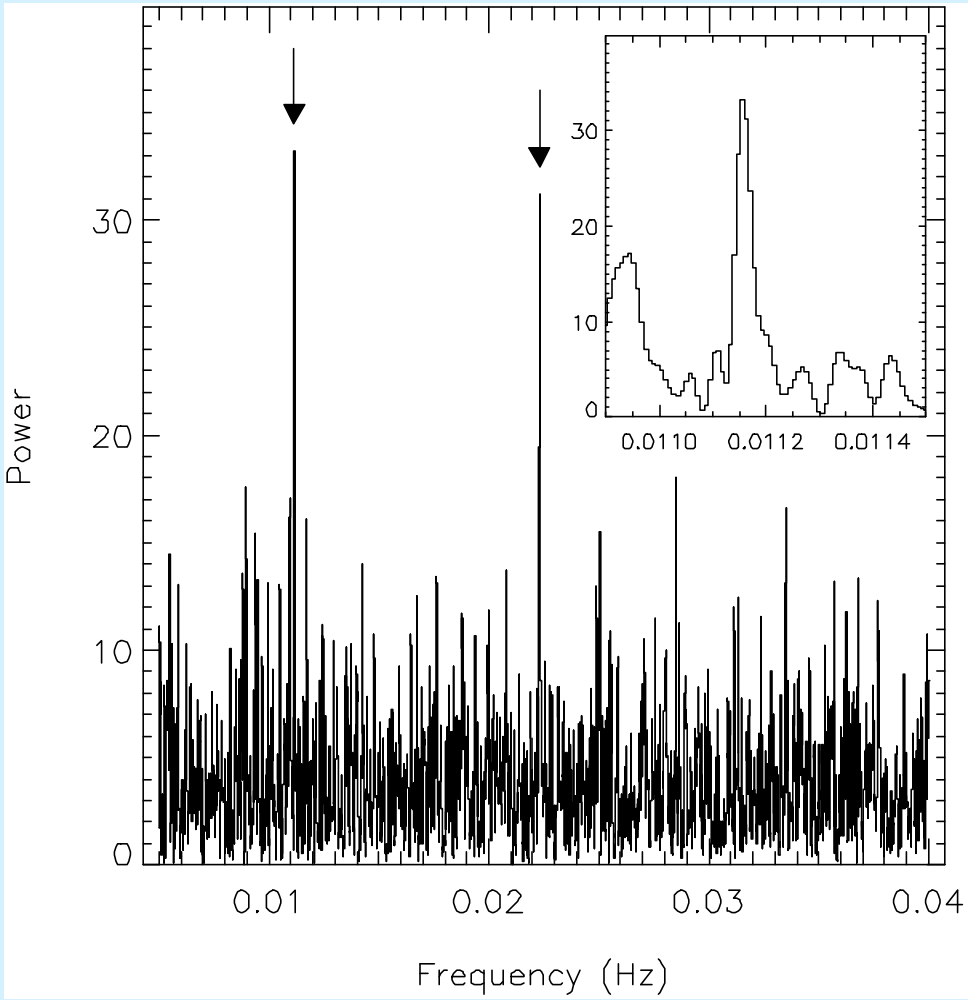
Chandra ACIS-I



RA: $19^h04^m47.5^s$
Dec: $09^o02'41.4''$
Error: 0.6” (90% cl)

Limiting X-ray flux:
~1.2×10^{-15} erg/s/cm^2

Z_2^2 Period Search



$P(Z^2_{max}) \sim 89.6$ s

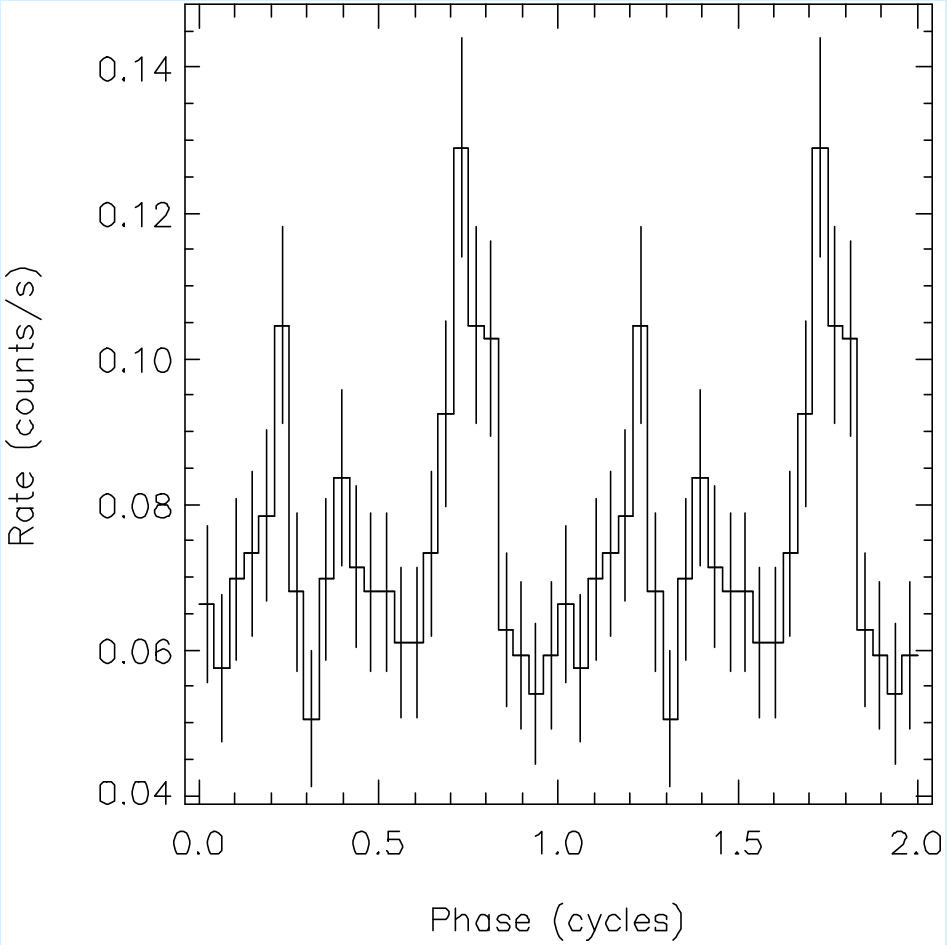
Reliability Check:

Generated 10^6 data sets, each contained 961 photons randomly distributed over 13.4 ks time span

For 41 sets $Z^2_{max} > 33.4$

→ Chance coincidence probability: 4.1×10^{-5}

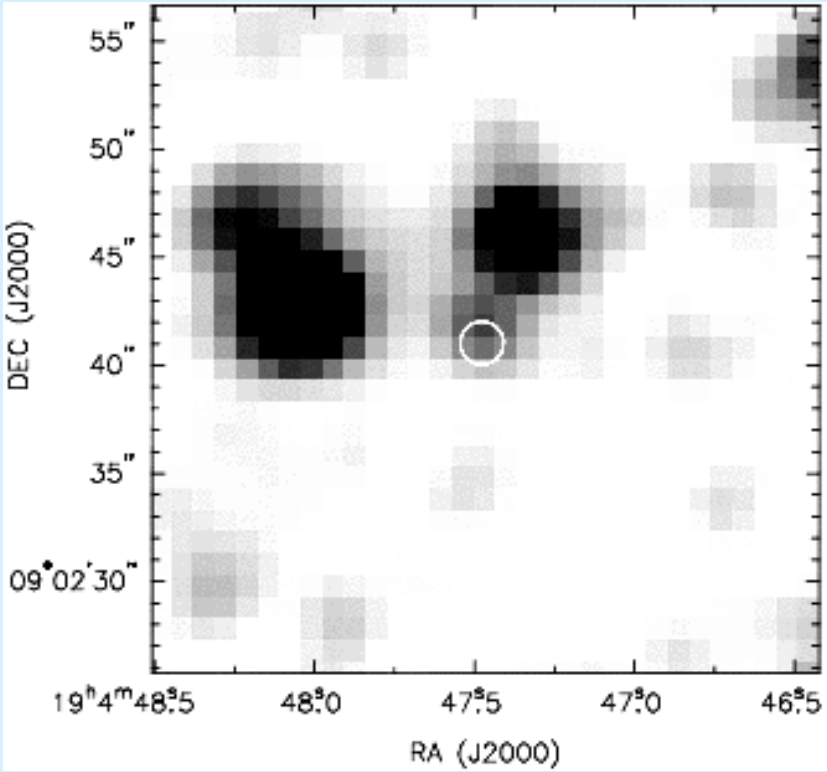
Pulse Profile in 2003



Different from pulse profiles in 1996 and 1998.

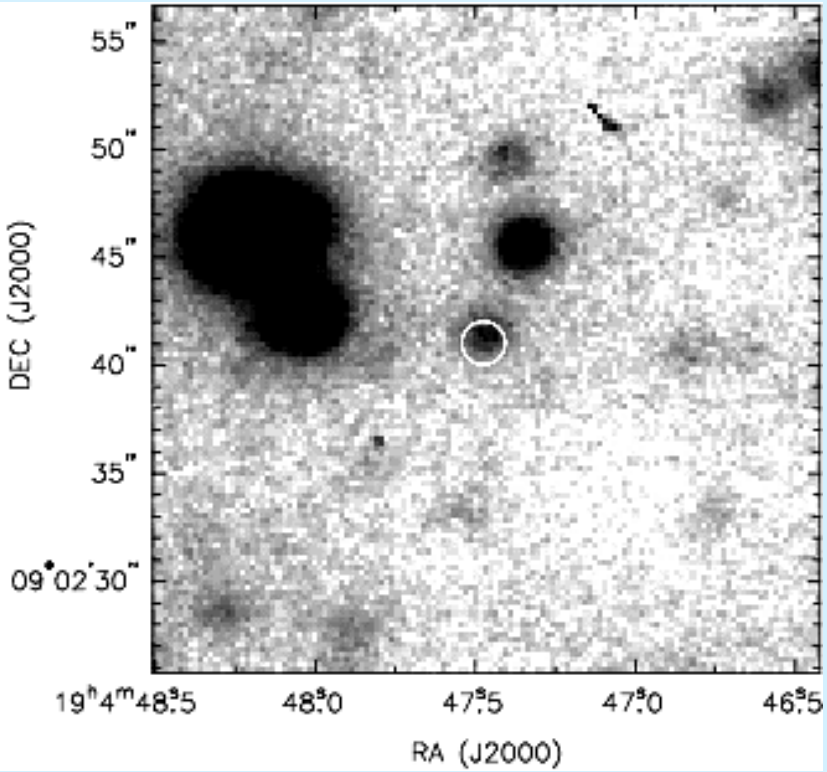
Nevertheless, it resembles the one in 1996 more.

2MASS



J = 15.2, H = 14.2, K = 13.5

RTT150



R = 18.7

Chance coincidence probability:
~7.5×10^{-3}

Spectral Properties

Spectrum well described with an absorbed power law model ; $n_H = 3.1 \times 10^{22}$ cm^{-2} and Γ=1.3.

Or equally well with an absorbed blackbody model; $n_H = 1.6 \times 10^{22}$ cm^{-2} and kT = 1.5 keV.

No evidence for Fe line.

$$F_x(1\text{-}10\text{keV}) = 3.1 \times 10^{-12}\ \text{erg/cm}^{-2}\text{/s}$$

Summary and Discussion-I

3 outburst episodes were observed:

- 1996 : L ~ 7×10^{34} erg/s
- 1998 : L ~ 7×10^{36} erg/s
- 2003 : L ~ 4×10^{34} erg/s

(assuming d = 10 kpc)

Frequency rates in between outbursts:

1996 → 1998 : -5.7×10^{-14} Hz/s

1998 → 2003 : -3.9×10^{-13} Hz/s

→ Increased by a factor of ~7

Summary and Discussion-II

Cepheus X-4: Exhibited 3 isolated outburst episodes (1988, 1993, 1997). Frequency rate increased by a factor of 10 in the second interval

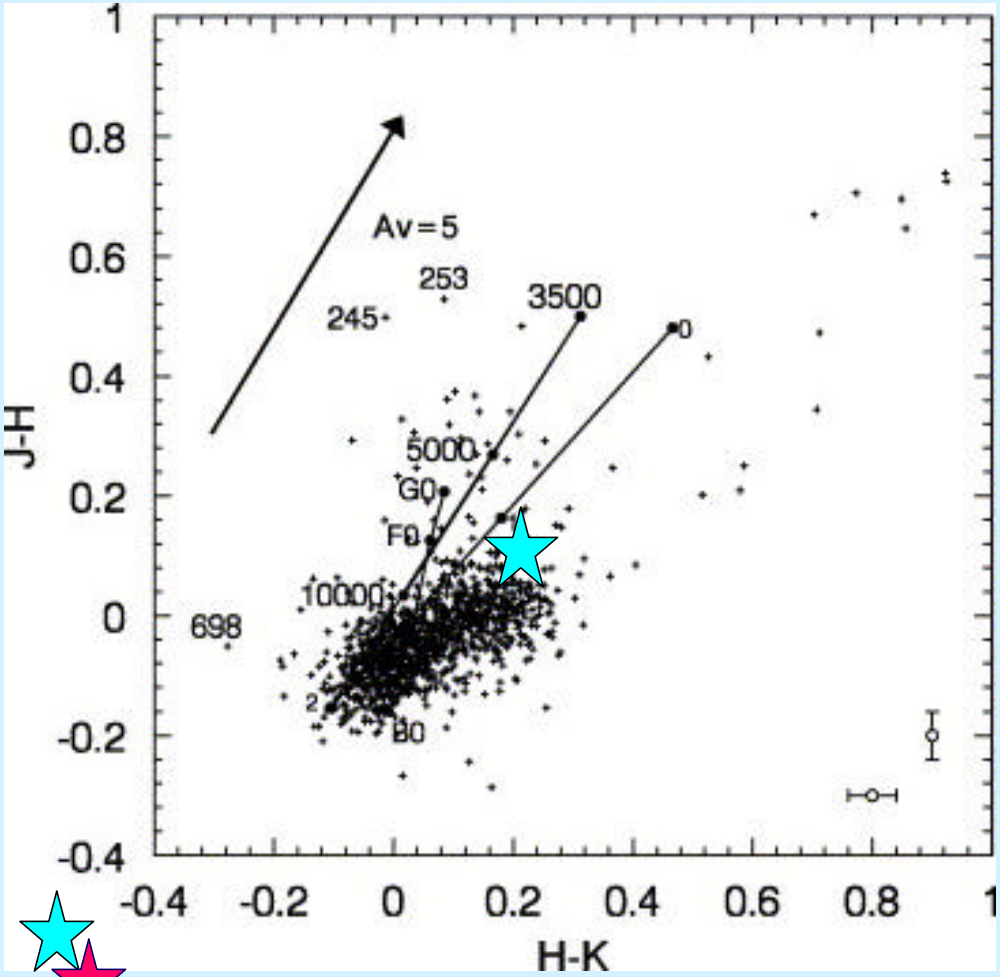
4U 1145–619: Displays outbursts that are almost equal in duration but with very wide range of energies.

SAX J2103.5+4545: Showed ~200 long outburst in 1999/2000 with $L \sim 10^{35}$ erg/s

X Persei: A persistent source, always in quiescence

Summary and Discussion-III

On the IR counterpart of XTE J1906+090



GRO 2058+42

(Zhang et al. 2005)

Basics of Accretion

- r_a (accretion radius), r_m (magnetospheric radius), r_c (corotation radius)
- $r_a > r_m$ and $r_c > r_m$: magnetically controlled accretion
- $r_c < r_m < r_a$: centrifugal inhibition of accretion. By imposing $r_m = r_c$ a minimum L can be obtained
- $r_m > r_a$: disk formation may be affected

(Stella, White & Rosner 1986)

Summary and Discussion-IV

$F_{x,min}$=5x10^{-11}erg/cm-2/s $k^{7/2}$ m_{30}^{2} $M_{1.4}^{-2/3}$ R_{6}^{-1} $P_{89.6}^{-7/3}$ d_{kpc}^{-2}

For XTE J1906+090 in 2003:

F_x(1-10 keV) = 3.1x10^{-12} erg/s/cm^2

Pulsations seen → system is in the mass accretion regime;

$$F_x >\sim F_{x,min}$$

$$d >\sim 4.0\ k^{7/4}\ \mu_{30}\ \text{kpc}$$