# Nearly simultaneous optical/X-ray observations of RXJ0806.3+1527


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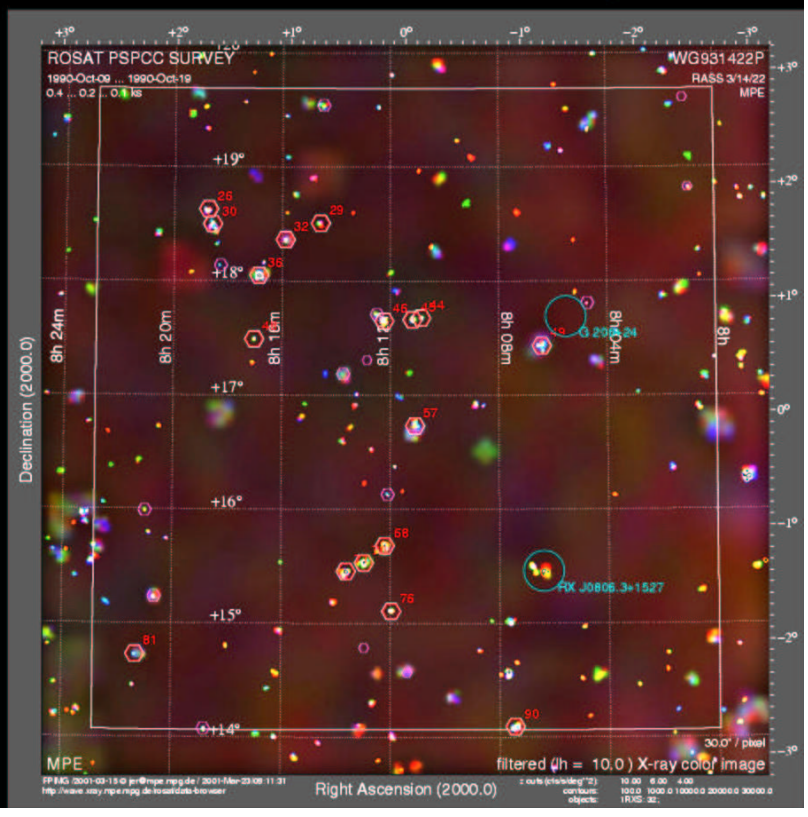
## Outline

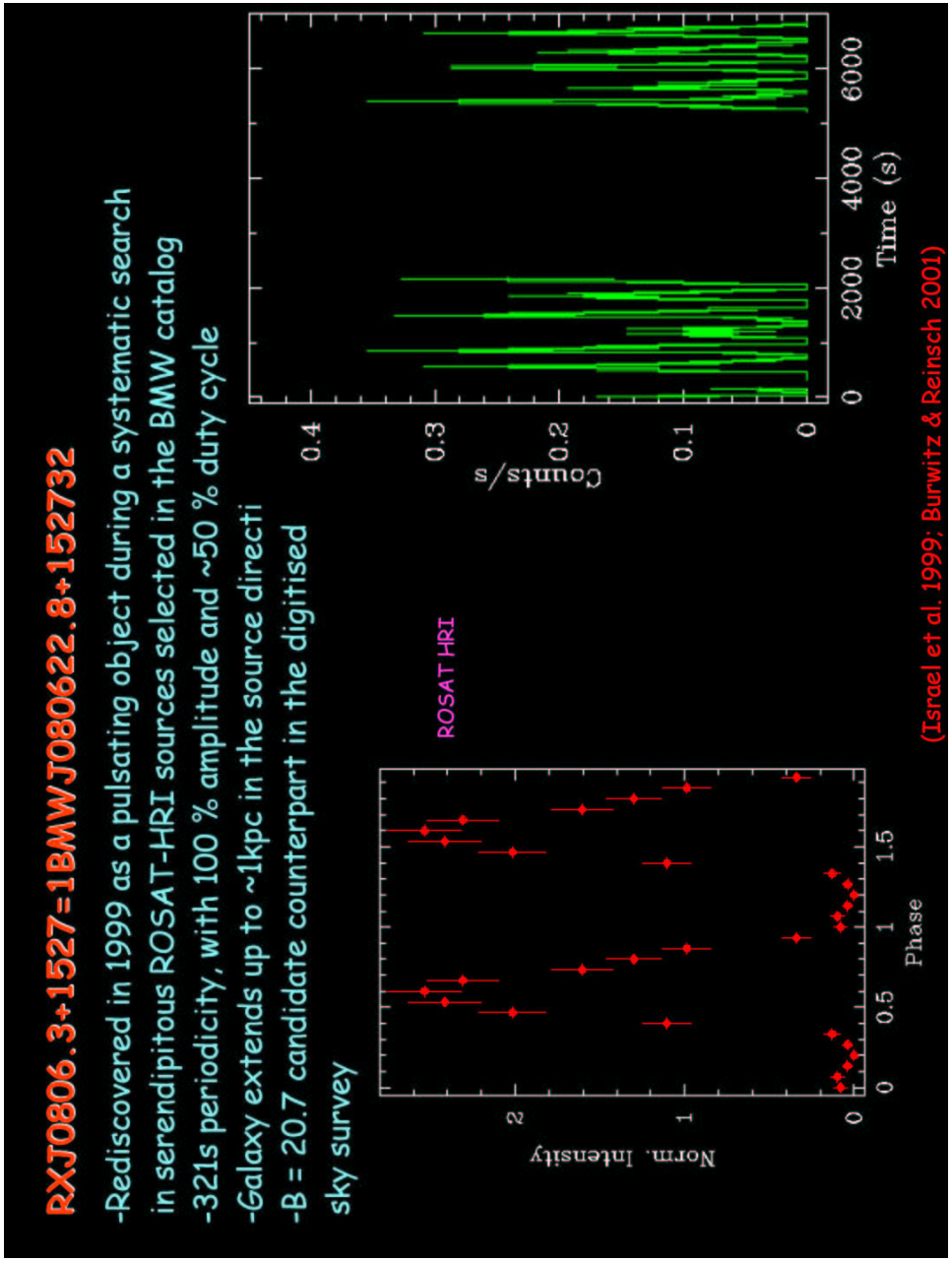
- Brief history of the source
- Results of the 2001 and 2002 X-ray/optical campaign
- Comparison with possible related objects and conclusions

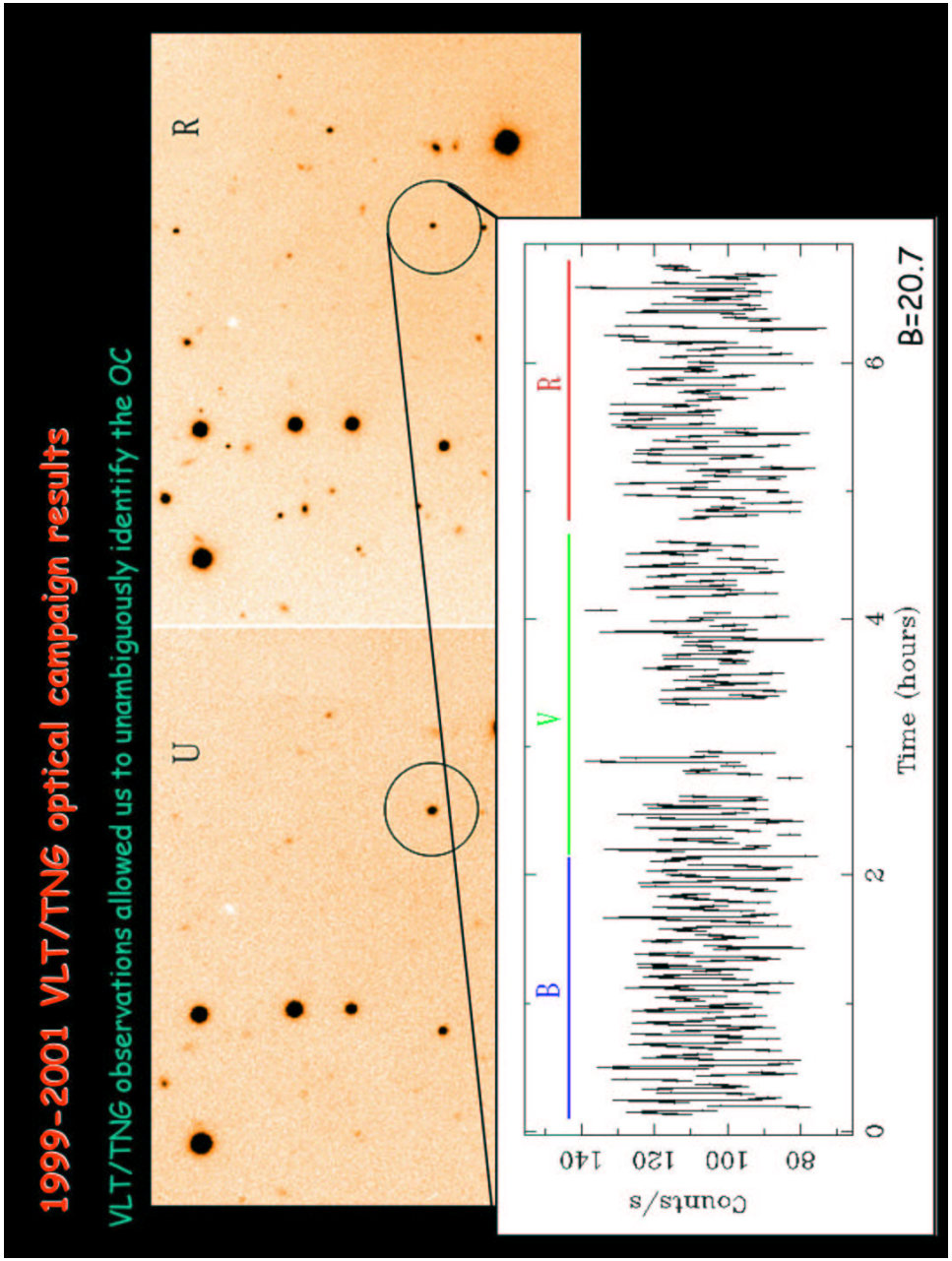
## RXJ0806.3+1527

-Discovered in 1990 in the RASS and classified as a soft variable CV, possibly of the IP class

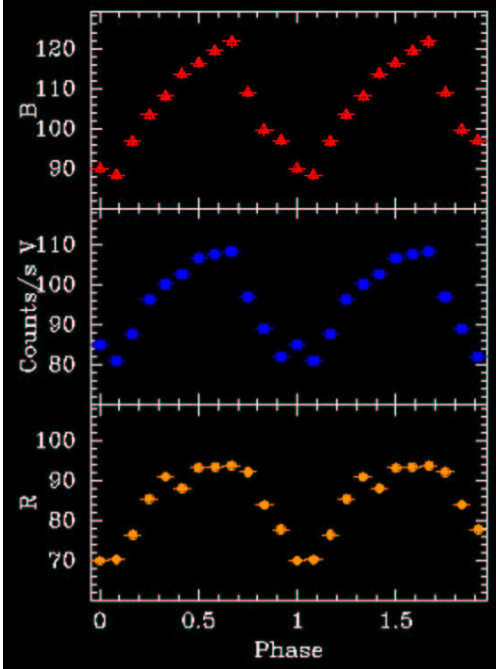
(Beuermann et al. 1999)

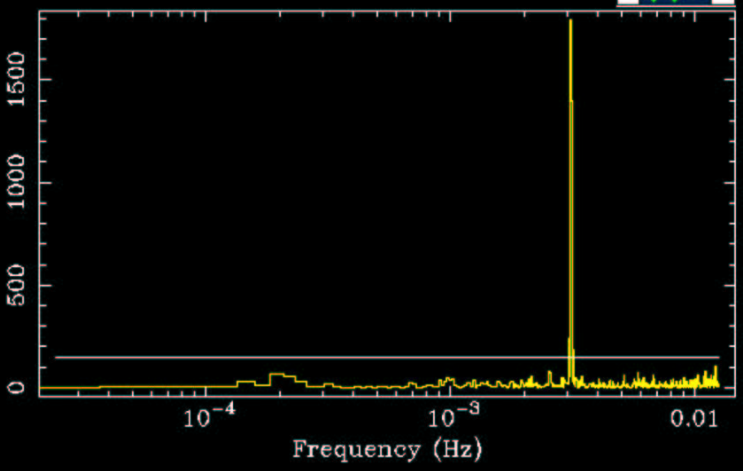



RXJ0806.3+1527=1BMWJ080622.8+152732
-Rediscovered in 1999 as a pulsating object during a systematic search in serendipitous ROSAT-HRI sources selected in the BMW catalog
-321s periodicity, with 100 % amplitude and ~50 % duty cycle
-Galaxy extends up to ~1kpc in the source directi
-B = 20.7 candidate counterpart in the digitised sky survey
ROSAT HRI
Norm. Intensity
Phase
Counts/s
Time (s)
(Israel et al. 1999; Burwitz & Reinsch 2001)


1999-2001 VLT/TNG optical campaign results
VLT/TNG observations allowed us to unambiguously identify the OC
U
R
B
V
R
B=20.7
Counts/s
Time (hours)

## 2001 photometry @ TNG:




Pulsed fraction: B 13.9+/-0.5%
V 14.2+/-0.6%
R 13.2+/-0.6%

(Israel et al. 2002)

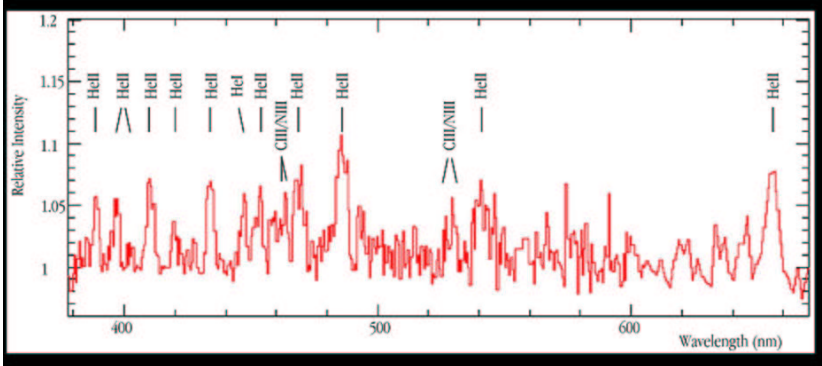
- Optical pulsations at the X-ray period (~14 % amplitude)

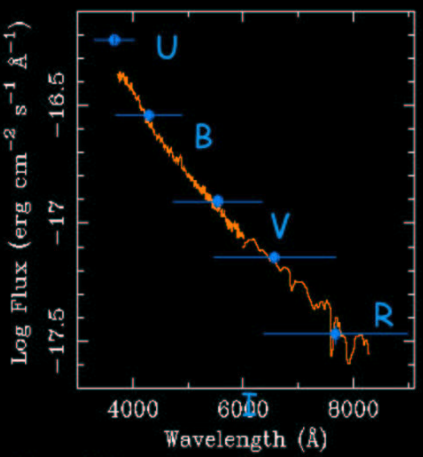
- No other periodicity detected (~1 min to ~5 hr, amplitude upper limit of 1.5 %)

Independent ident. of the OC from an other group (based on optical photometry; Ramsay et al. 2002)

## 2001 spectroscopic VLT observations :

The most important piece of information cames from the optical spectrum




18000s spectum of the V=21.1 counterpart

-HeII lines from Pickering series + HeI

- 1600 km/s FWHM

- EW ~ 2-6 A
o

- No absorption lines

Very blue thermal continuum (T > 40,000 K) not consistent with any class of mCV

The study and interpretation is complicated by the likely emission of CIII/NIII close to the HeII emission lines and from the effects of X-ray excitation which affect the line intensity ratios

## Our proposed scenario

- 321s represents the orbital period of the system;
- HeII line large width due to orbital motion (from the X-ray irradiated companion surface);
- Optical pulsations mainly from the X-ray irradiated surface of the companion;
- Optical continuum likely originated from X-ray irradiated donor surface, (possibly also from the stream, and part of the accretor);
- 0.13 Msol secondary, 0.2-0.9 Msol primary (if stable accretion) ;
- Moreover combining $R_L$ with the Kepler law $\rho_2 \sim 2 \times 10^4$ g/cm$^3$ (excluding a MS star);
- Not possible to discern between magnetic and non-magnetic system

RX J0806.3+1527: The shortest orbital period binary known

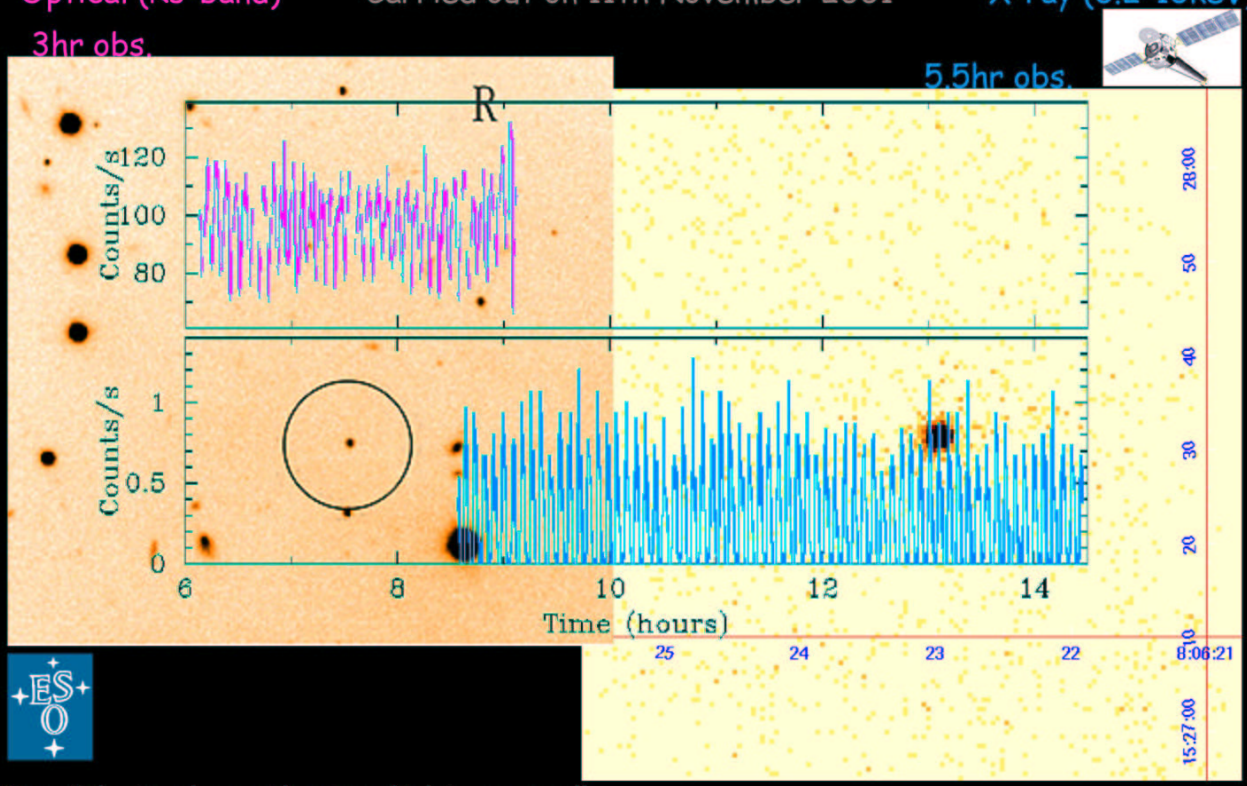
(Cropper et al. 2000; Marsh & Steeghs 2002; Wu et al. 2002)

made up by two He white dwarfs.

Simultaneous obs. Goals :
- Characterise the X-ray spectrum (ROSAT HRI does not have energy resolution)
- Phase the X-ray and optical modulations
- Determine the possible modulation secular evolution

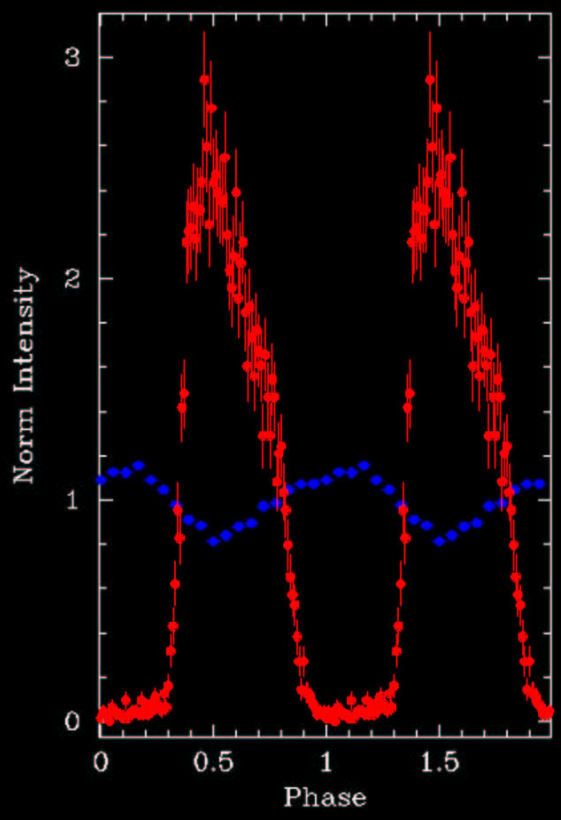
## Contiguous and (partially) simultaneous Chandra/VLT observations

Optical (Rs-band) — Carried out on 11th November 2001 — X-ray (0.2-10keV)




Possible to phase the two light curves !!

## Phasing the X-ray-to-optical emission




- X-ray and optical curves shifted of about 0.4 in phase (0.5 assuming the optical minimum) in agreement with X-ray irradiation

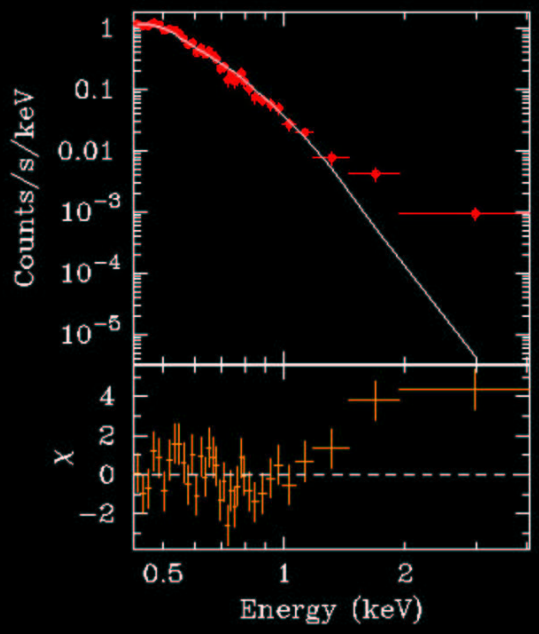
Chandra P = 321.51 +\- 0.03 s
(Israel et al. 2003, subm.)

ROSAT P = 321.5393(4) s
assuming no Pdot
(Burwitz & Reinsch 2001)

(X-ray/optical modulation it is not indicative of mass trasfer. X-ray/optical out of phase lightcurves are instead a likely signature of an interacting binary)

## Chandra ACIS energy spectrum

Consistent with a BB with kT of about 70eV emission from a small region.




Phase-averaged 0.1-2.5 keV flux $10^{-12}$ erg $s^{-1}$ $cm^{-2}$

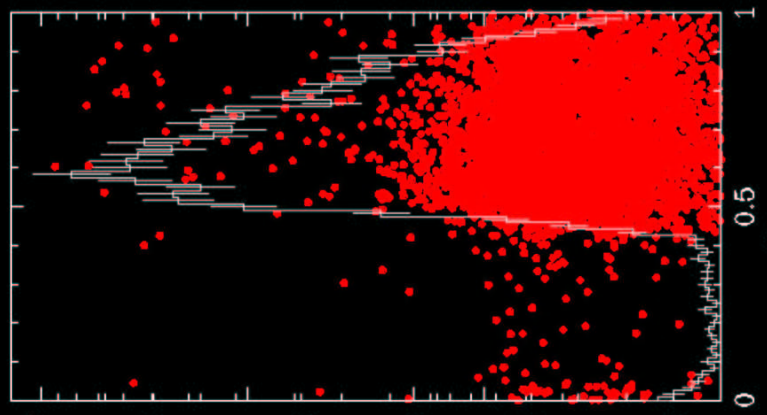
Evidence for a high energy tail.....
..... however

Possible effects due to ACIS pile-up !

(Israel et al. 2003, subm.)

## Chandra ACIS energy spectrum - 2

Sufficently high number of photons to perform a PPS analysis to check the percentage of pile-up as a function of intesity (and therefore phase).




## Pulse Phase Spectroscopy

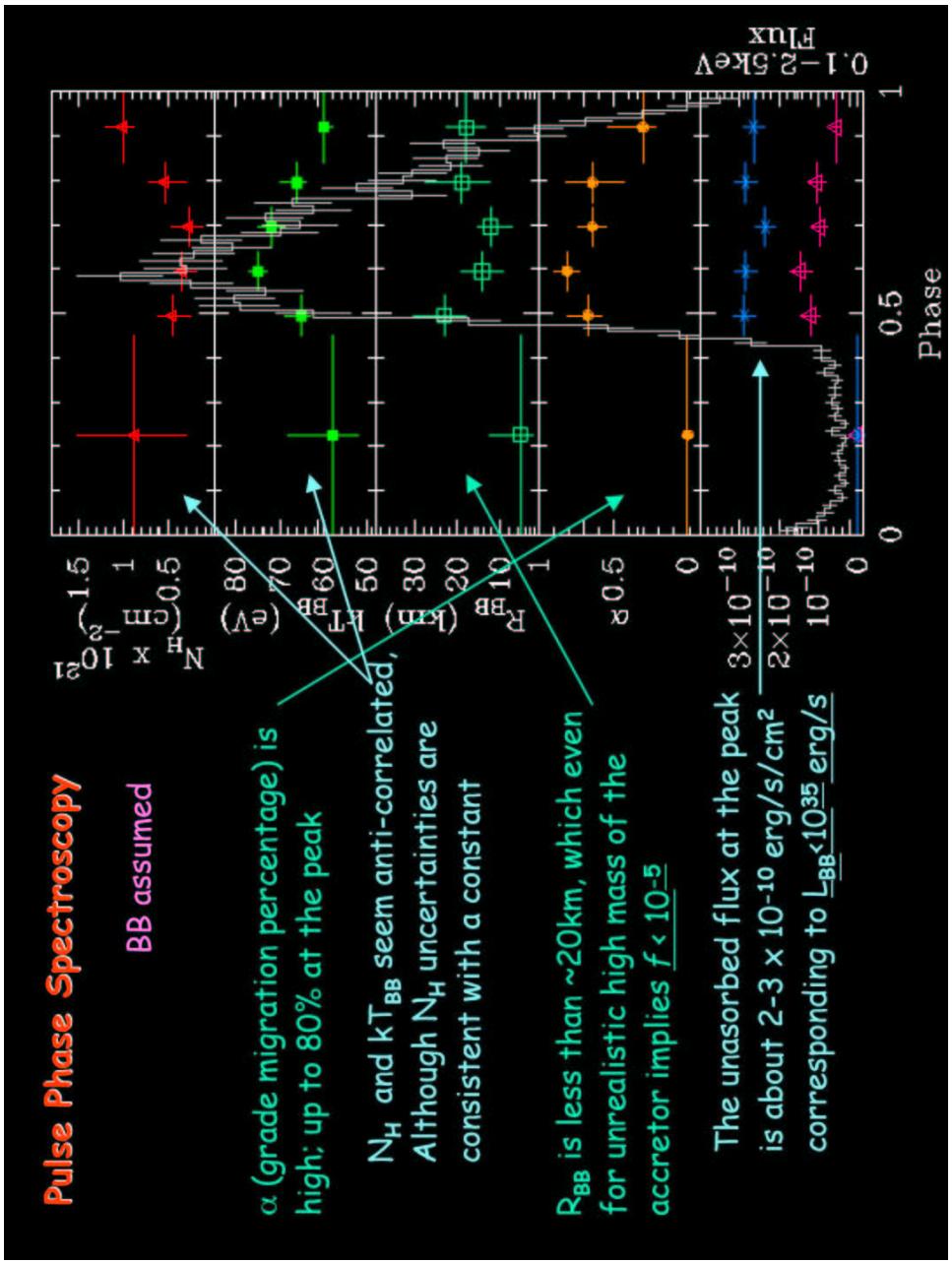
BB assumed

α (grade migration percentage) is high; up to 80% at the peak

$N_H$ and $kT_{BB}$ seem anti-correlated, Although $N_H$ uncertainties are consistent with a constant

$R_{BB}$ is less than ~20km, which even for unrealistic high mass of the accretor implies $f < 10^{-5}$

The unasorbed flux at the peak is about 2-3 x $10^{-10}$ erg/s/cm² corresponding to $L_{BB} < 10^{35}$ erg/s



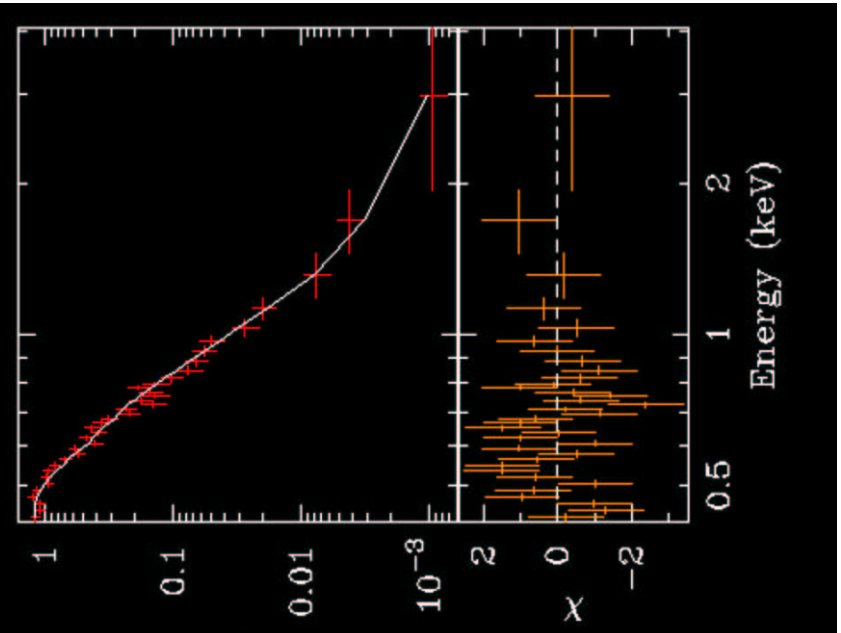
## Corrected energy spectrum

Pile-up strongly affects the Chandra spectrum !!

However the correction seems to properly model the distorted spectrum. Better calibration will be released in the future

No high energy component !!

Check performed on an outer annulus region; same spectral shape but $\alpha$=0



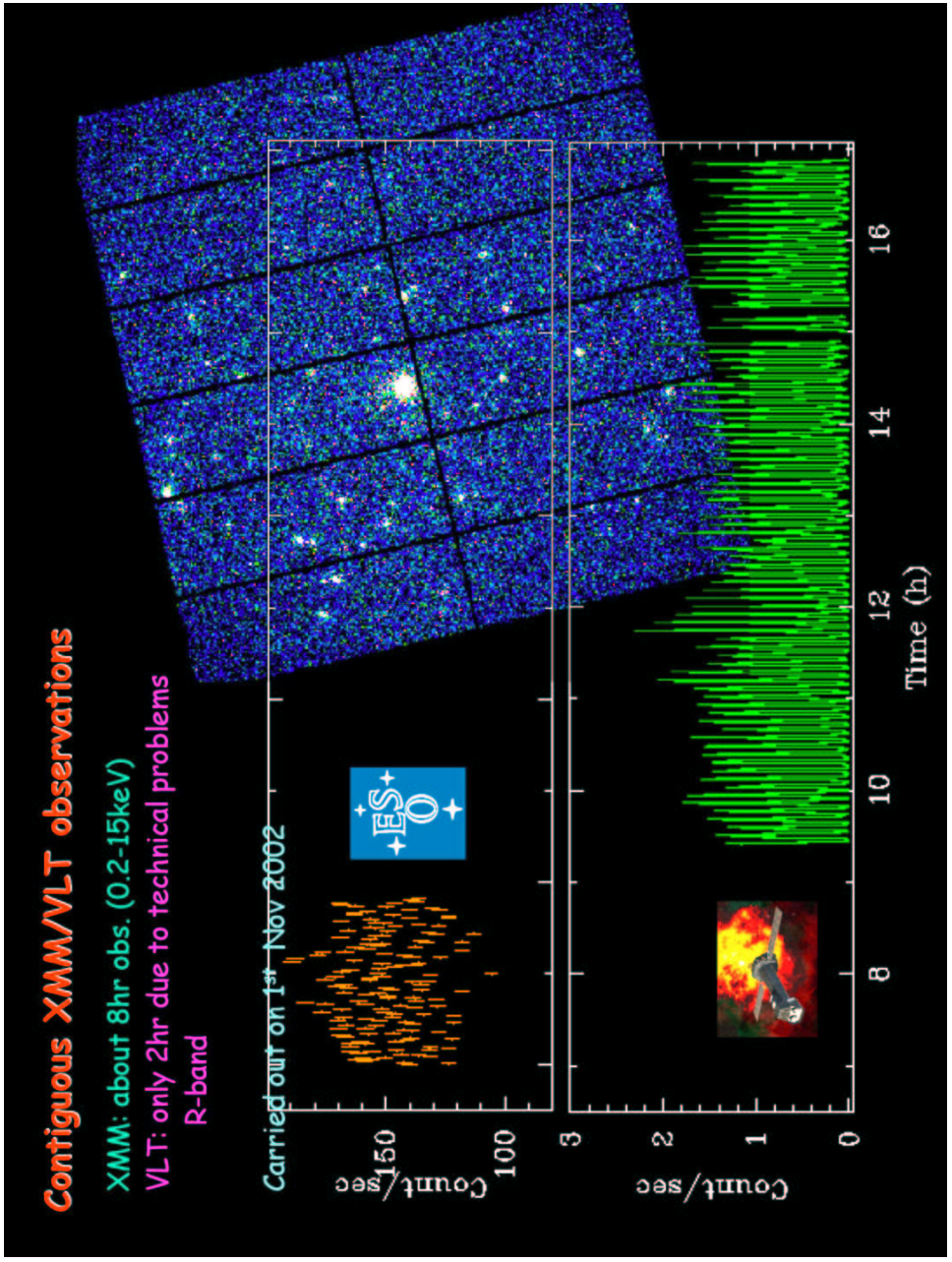

## Contiguous XMM/VLT observations

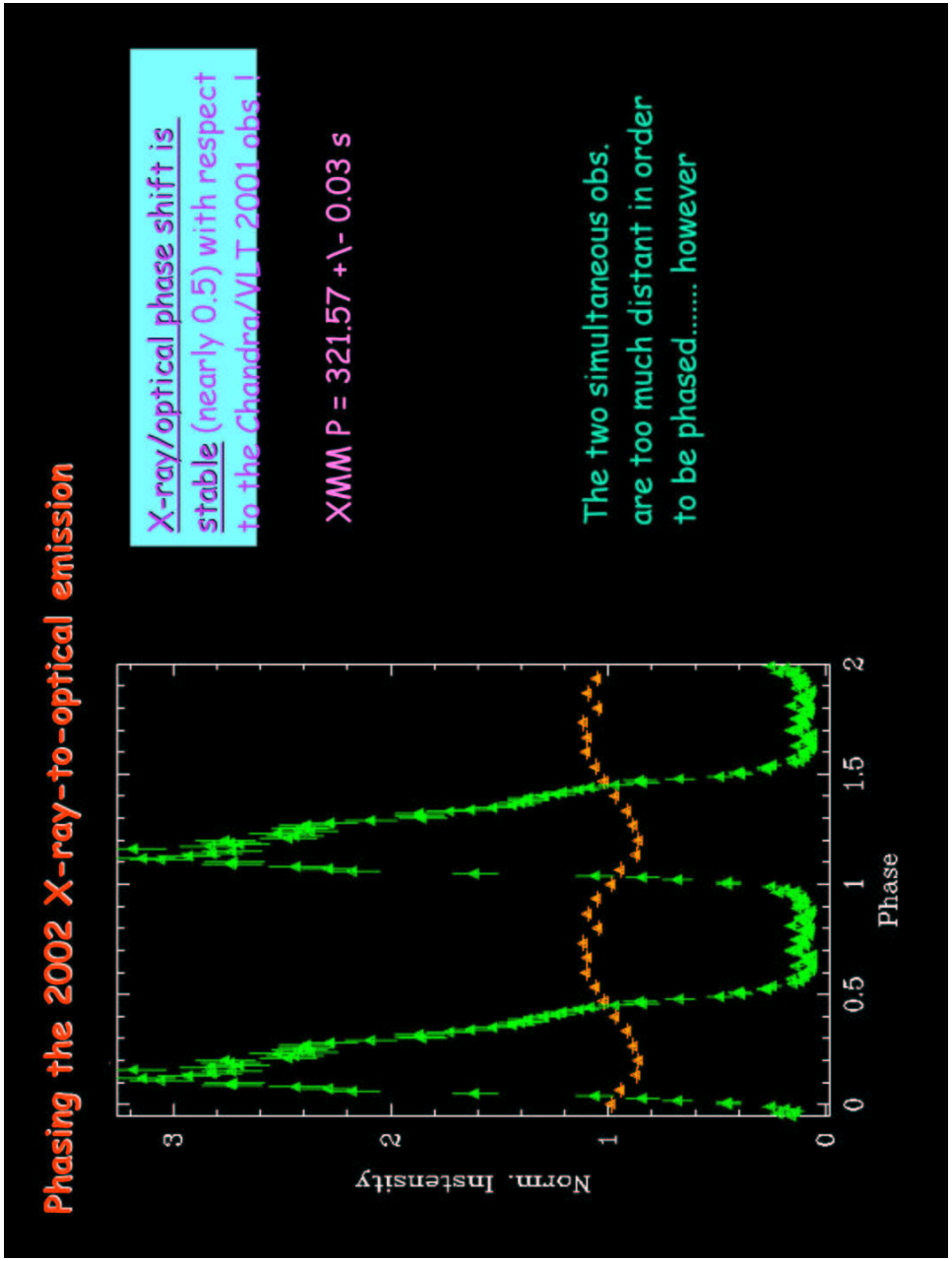
XMM: about 8hr obs. (0.2-15keV)

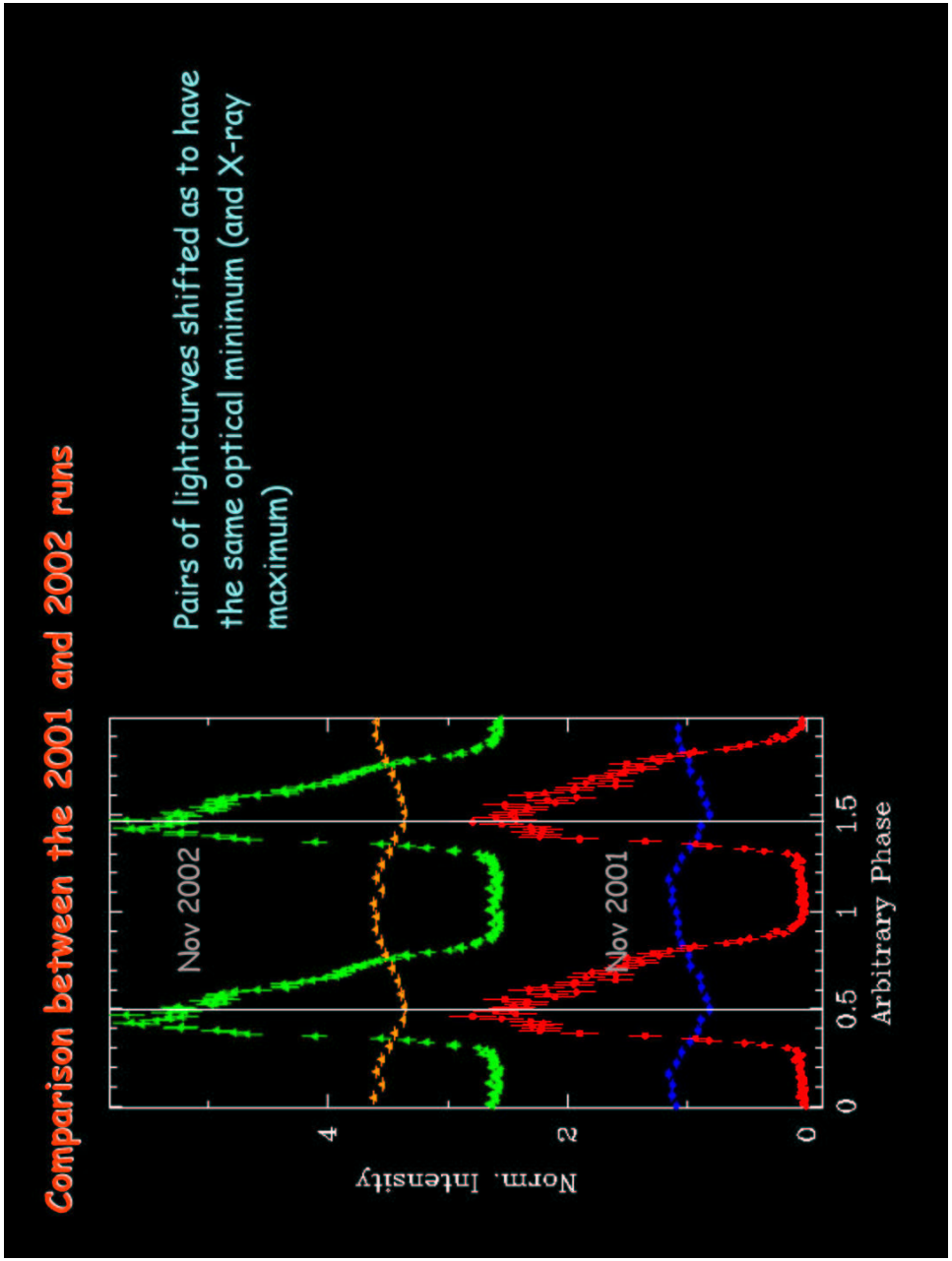
VLT: only 2hr due to technical problems

R-band

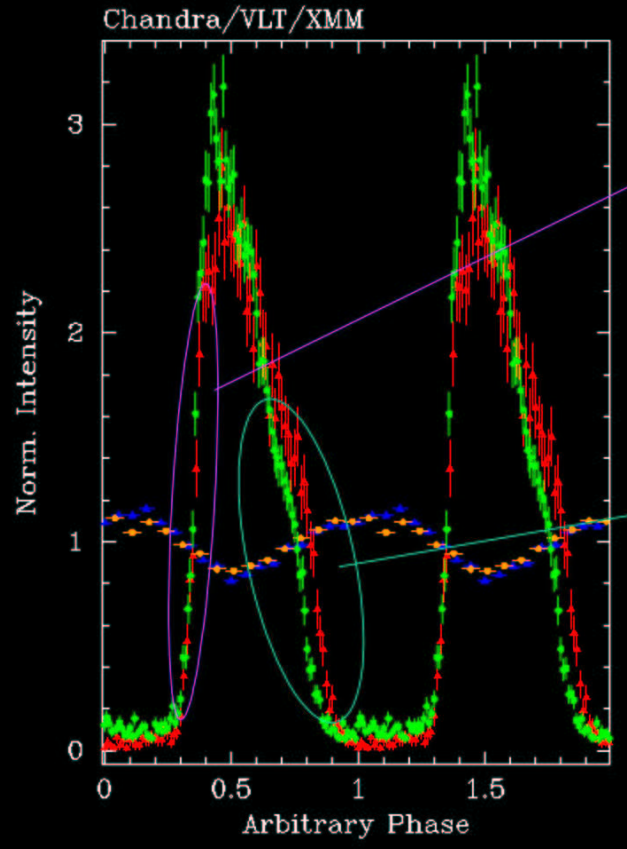
Carried out on 1st Nov 2002




Phasing the 2002 X-ray-to-optical emission
X-ray/optical phase shift is stable (nearly 0.5) with respect to the Chandra/VLT 2001 obs. !
XMM P = 321.57 +\- 0.03 s
The two simultaneous obs. are too much distant in order to be phased..... however
Norm. Intensity
Phase


Comparison between the 2001 and 2002 runs
Pairs of lightcurves shifted as to have the same optical minimum (and X-ray maximum)
Nov 2002
Nov 2001
Norm. Intensity
Arbitrary Phase

## Comparison between the two runs - 2



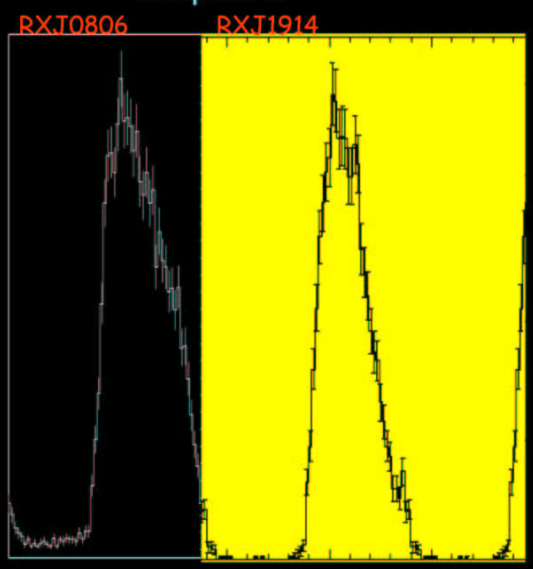

The shape of the rising part is unchanged (in the DIA model would correspond to the sharp exit of the hot spot from self-occultation; but see also DD and FoSf IP models)

Variations in the tail which implies also a change in the on-off ratio (in the DIA model this part likely originates from the variations of accretion stream and the X-ray irradiated surface of the companion)

## Comparison with related object(s)

Similarities with RXJ1914+24:

- pulse profile (shape, off/on ratio, X/optical shift)
- soft spectrum (BB with kT < 100 eV for RXJ1914); no hard component
- no additional modulation
- no signatures for a MS companion




Differences:

- no emission lines (but low sensitivity spec. for RXJ1914; high $N_H$)
- a factor of 10-20 less luminous than RXJ1914 (Warning..... RXJ1914 is variable, and both the ASCA and Chandra low-energy response are not yet well known)

RXJ0806 and RXJ1914 belong to

## Comparison with stream-fed IPs

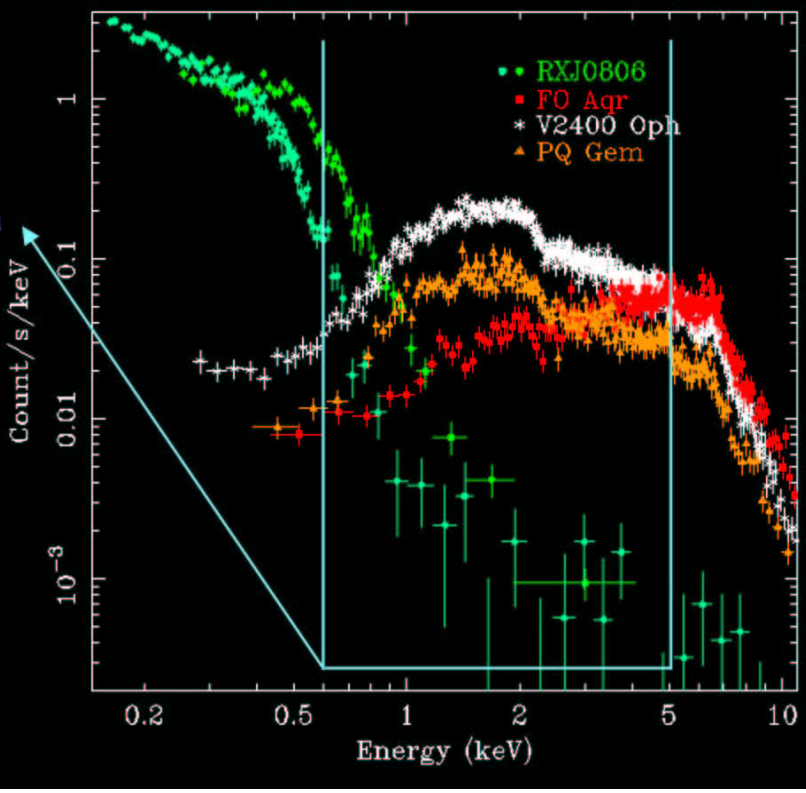
RXJ0806 and RXJ1914 proposed as first examples of stream-fed face-on IPs (Norton et al. 2002)

If correct they should be similar to FO Aqr, V2400 Oph and TX Col

Energy region over which ASCA and Chandra have similar response and comparison is meaningful

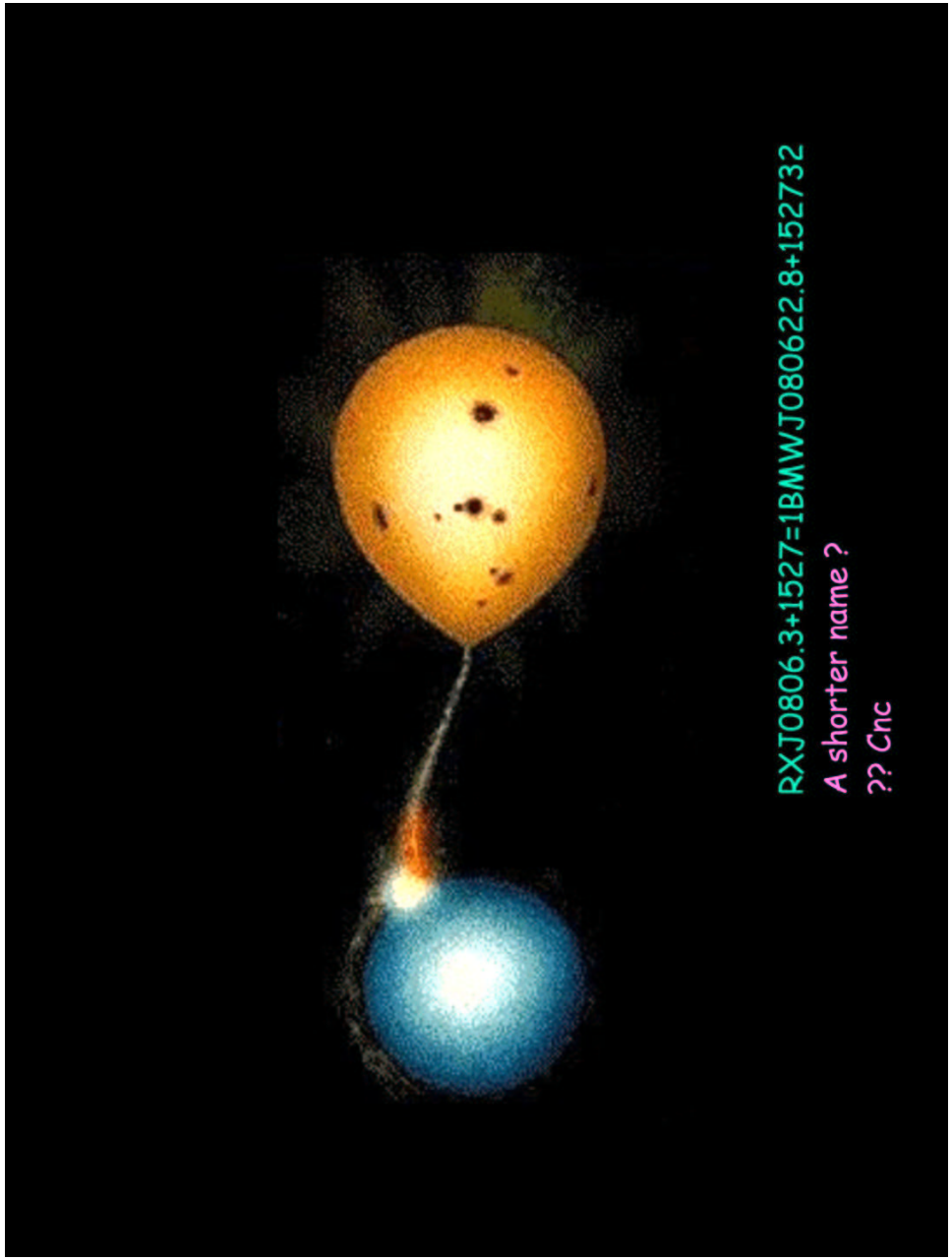
Implication: differences cannot be due only to geometrical effects (face-on versus other viewing angles)

(nearly flat optical spectrum continuum in stream-fed IPs)




## Summary

- X-ray and optical emission phase shifted of about 0.4+/-0.1 and constant on long time-scales. These findings are consistent with the X-ray reprocessing mechanism;
- X-ray spectrum consistent with a soft and small thermal emission (BB with kT~70eV and R ~20km) without higher energy component, consistent with the DD, DIA and UI models. BB radius seems to be smaller the case of MCVs
  - Maximum peak luminosity of $L_X<10^{35}$ erg/s. This is a factor of about 5 less the expected in the case of stable mass transfer driven by GW emission with strong coupling.
- The optical to X-ray spectrum not consistent with a single thermal component
  - RXJ0806 and RXJ1914 have similar optical/X-ray properties; objects of the same class
- X-ray (and optical) properties of stream-fed Ips are different to those of RXJ0806 (and RXJ1914)
  - The double degenerate scenario with a 5.4min orbital period seems the most probable. 1) If AM CVn-like something should happen when the orbital period approches 10min (X-ray switch-off/on ?), or 2) we are looking at two different evolutionary phases of the same class (RXJ0806 might correspond to a phase just before of AM CVn one).


RXJ0806.3+1527=1BMWJ080622.8+152732
A shorter name ?
?? Cnc