Hard X-ray emission from the accretion-disk boundary layer in symbiotic binaries

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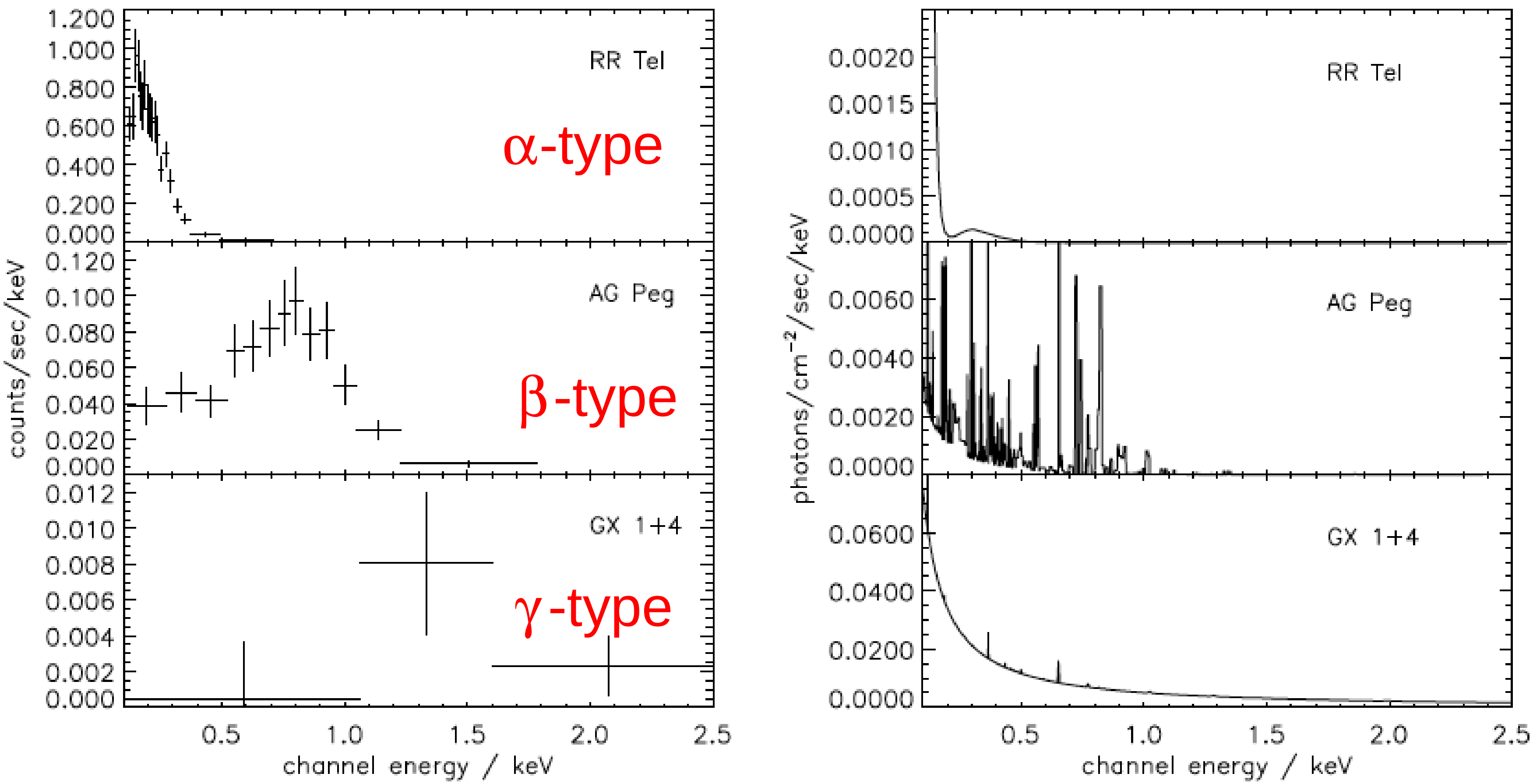
- **Symbiotic stars are wide binary systems composed of a red giant as donor and a hot component, usually a white dwarf as primary (Kenyon 1986);**
- **The whole system is surrounded by a ionized nebula;**
- **Accretion is thought to be mainly wind-driven, although evidence (e.g. flickering, jets, images) suggest the presence of accretion disk in some systems**

How did symbiotics looks in X-rays?

- Muerset et al. (1997) searched the RASS and found 16 symbiotic stars with basically three classes of pulse height distribution:
  - α-type: Super-soft emission
  - β-type: Emission from a thin plasma with a temperature of a few 10^6 K
  - γ-type: even harder emission (E > 2.4 keV)



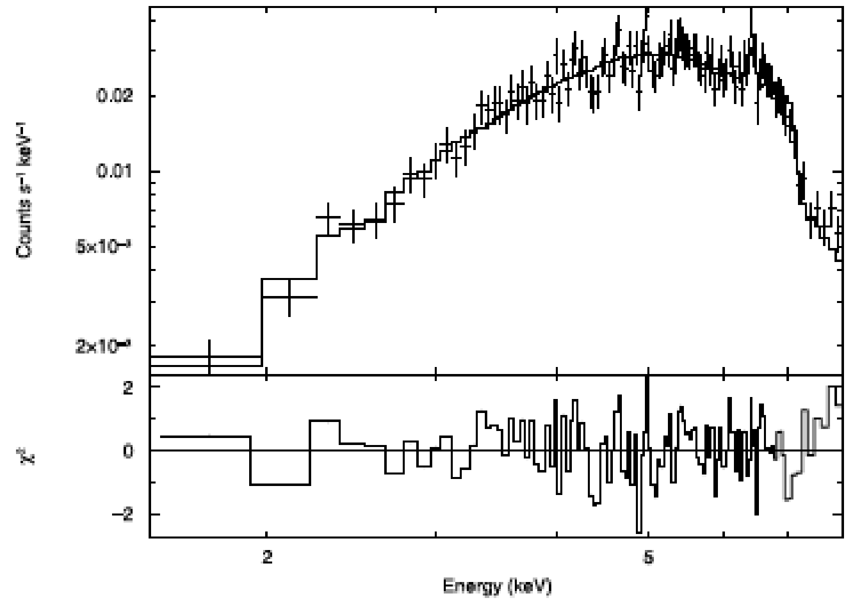
RR Tel
α-type
AG Peg
β-type
GX 1+4
γ-type
counts/sec/keV
channel energy / keV
photons/cm^{-2}/sec/keV
channel energy / keV

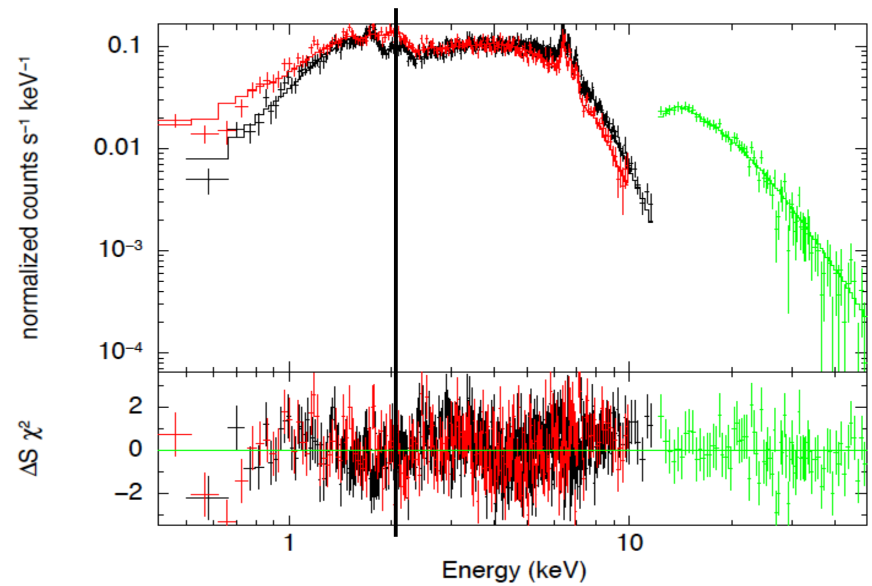
Hard X-ray symbiotics….

- In 2005, the paradigm that established that symbiotic stars were soft sources changed when RT Cru was detected with INTEGRAL and Swift/BAT (Chernyakova et al. 2005)
- Afterwards, Chandra observations showed that the spectrum was highly absorbed (n_H~10^{23} cm^{-2}) and can be modeled with a multi-temperature hot thin plasma with kT > 55 keV (Luna & Sokoloski 2007).

Suzaku observation in 2007 shows the same multi-temperature spectrum BUT with a soft component not detected before.

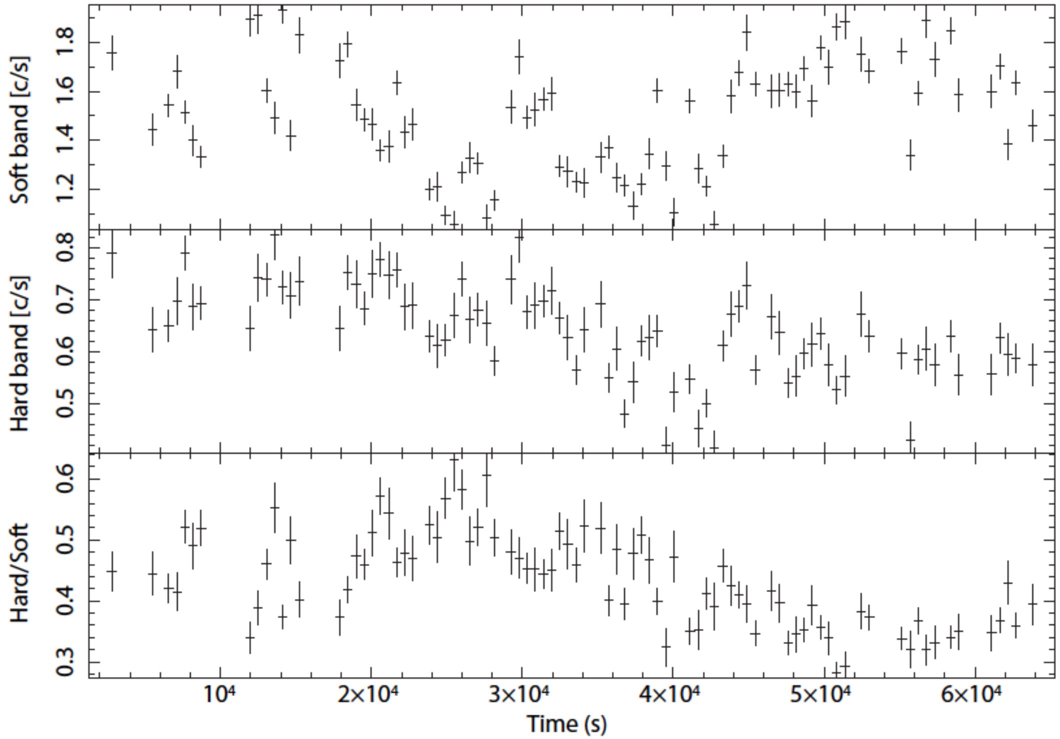
No periods are detected, magnetic accretion, in analogy with IPs, is unlikely.





Where is the hard X-ray emission coming from?

- Hard X-ray emission seems to be originated in the accretion disk boundary layer, in analogy with dwarf novae (e.g. Pandel et al. 2005)
- The presence of short term stochastic variability (i.e. flickering) in the X-ray light curves also support the accretion disk origin.



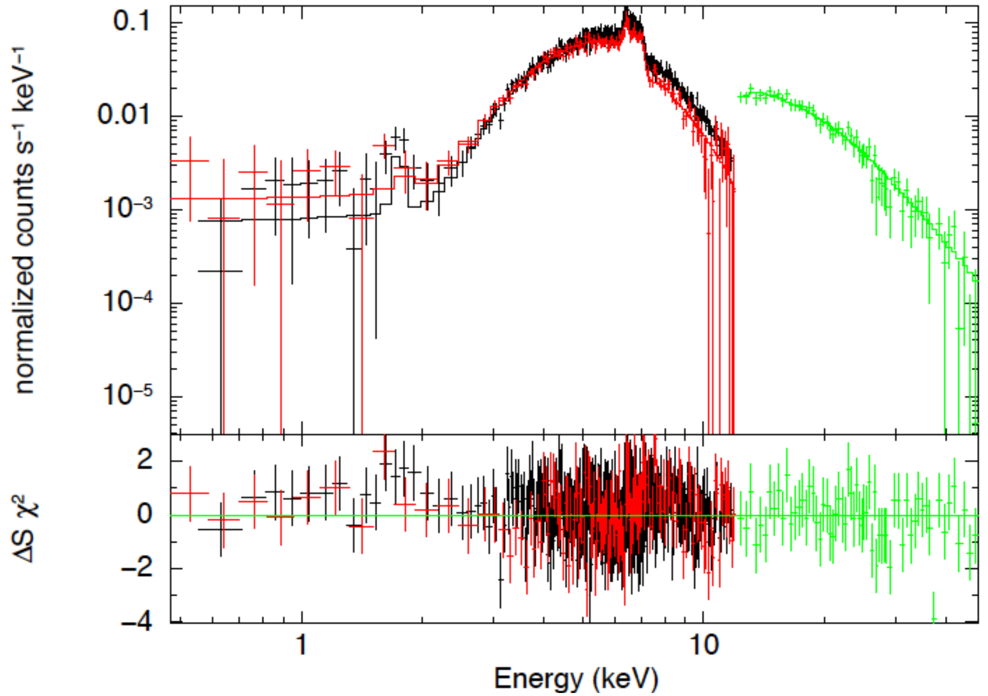
- How do we model the observed spectrum and what this models tell us?. We’ve been using the following model:

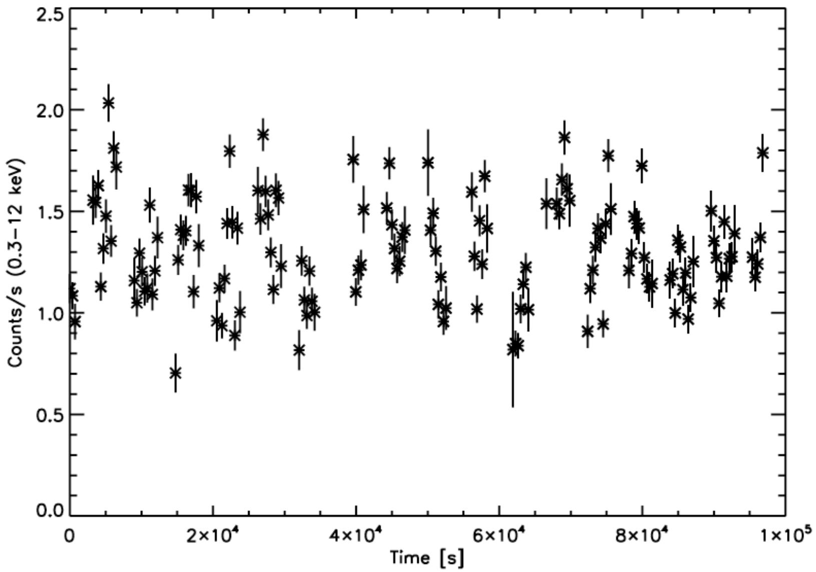
$$wabs*pcfabs*(mkcflow+gauss)$$

- In a cooling flow spectrum, the maximum temperature is mainly determined by the mass of the accretting object (assuming a shock in the boundary layer);
- Hard X-ray symbiotics seems to contain high mass white dwarf!;
- Temperatures of ~55 keV, imply masses of ~1.3 M_{sun}. Are they SNIa progenitors?;
- Is it valid the mass estimation using cooling flow parameters?: an interesting case is T CrB, which was detected by Swift/BAT (Kennea et al. 2009) and observed with Suzaku in 2007;

T CrB

- T CrB is a recurrent nova, with outburst approx. every 80 years. Models by Yaron et al (2005) suggest a white dwarf mass of ~1.3 Msun.
- Its X-ray emission indicates a maximum temperature of ~57 keV and therefore a high white dwarf mass
- In contrast with RT Cru, however, the absorption doesn't vary significantly (Kennea et al. 2009)



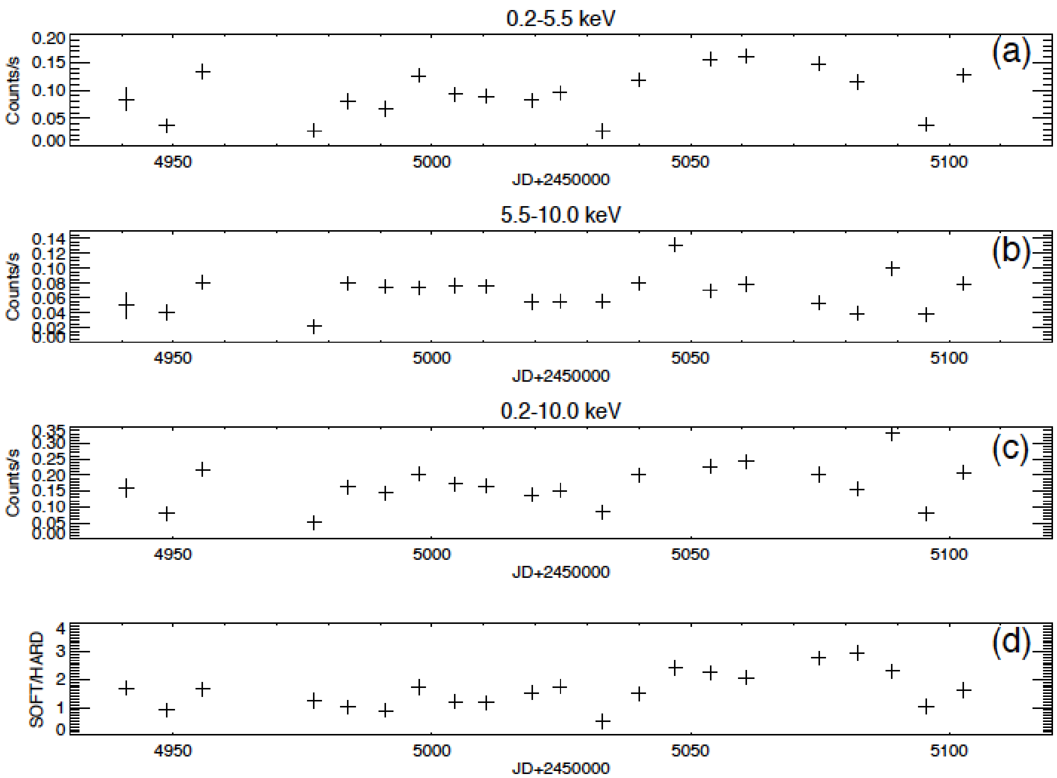


What's the origin of flux changes in RT Cru?

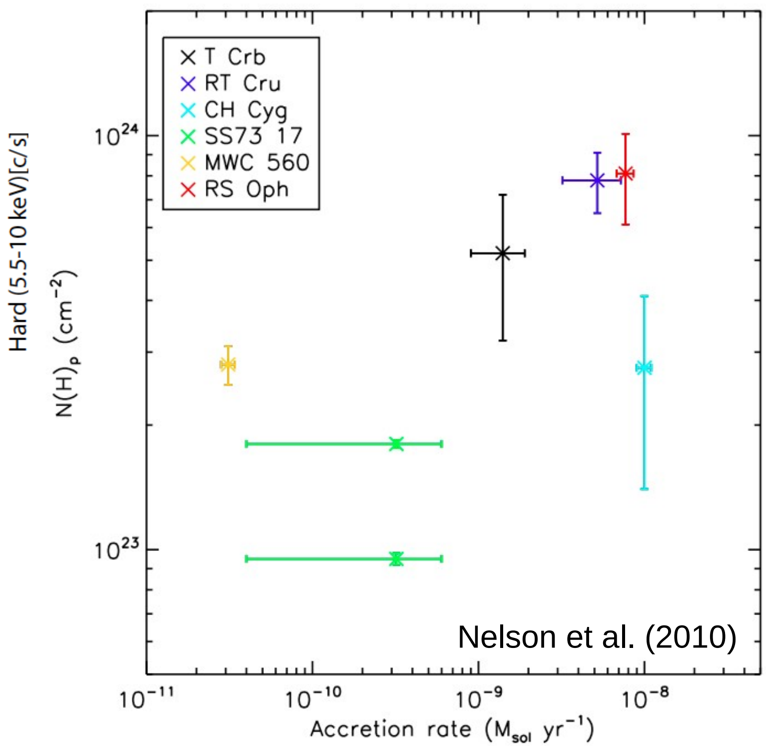
- We observed RT Cru with Swift XRT/UVOT for 3 ks during 6 months every week;

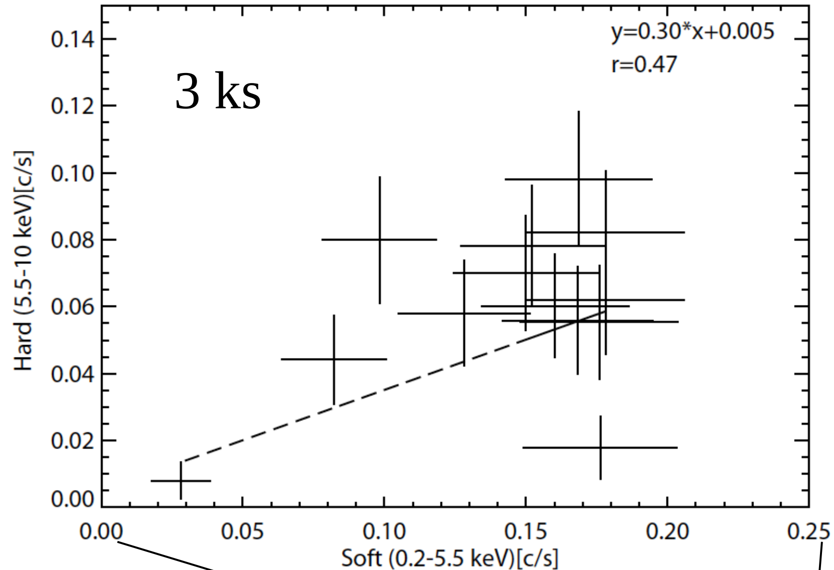
- The soft and hard X-ray fluxes, as well as the UV, are variable on times scales of a few minutes to weeks and months, however, no periodic oscillations are detected;

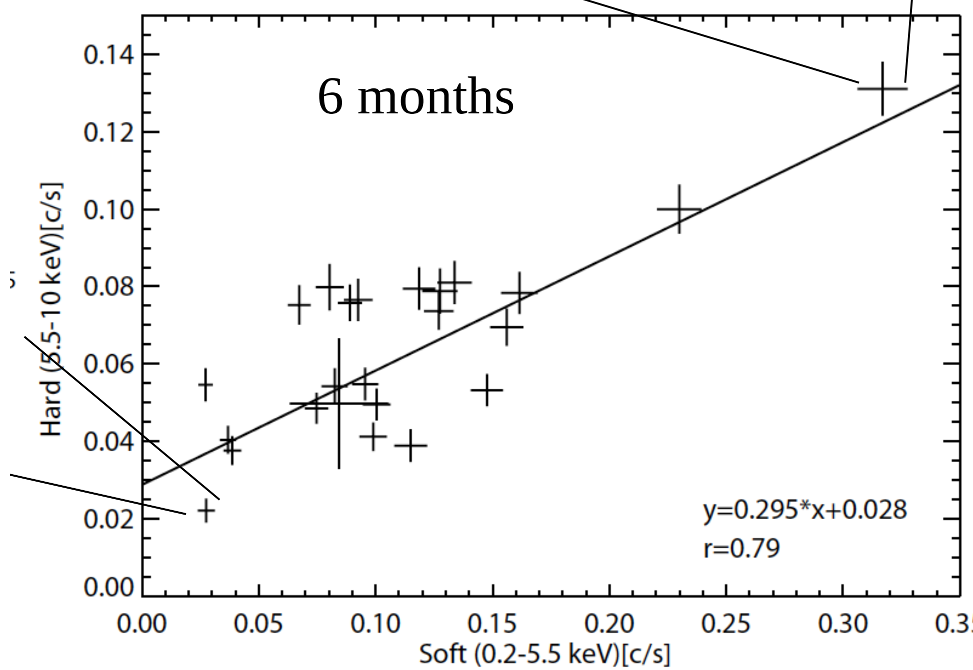
- The (uncertain) orbital ephemeris show that the X-ray flux changes are unlikely to be tied to orbital motions;



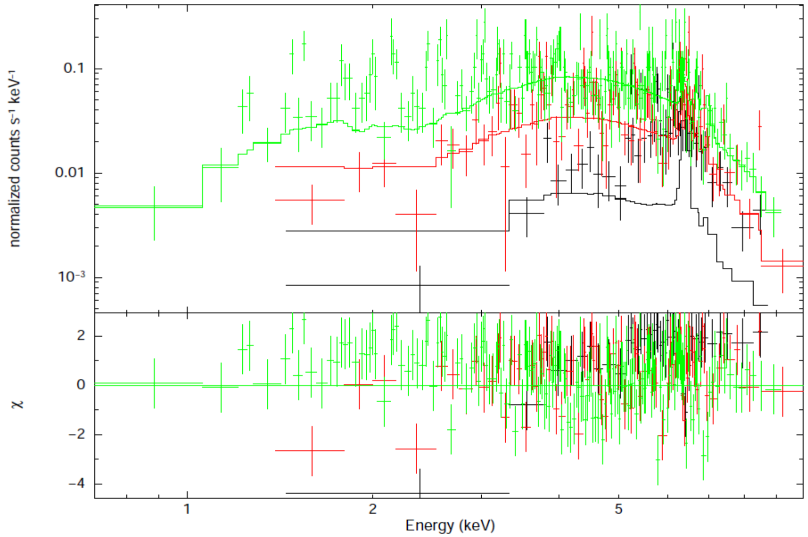
- If absorption is responsible for the flux changes in the soft energies, we would expect the hard flux to remain unchanged, however….





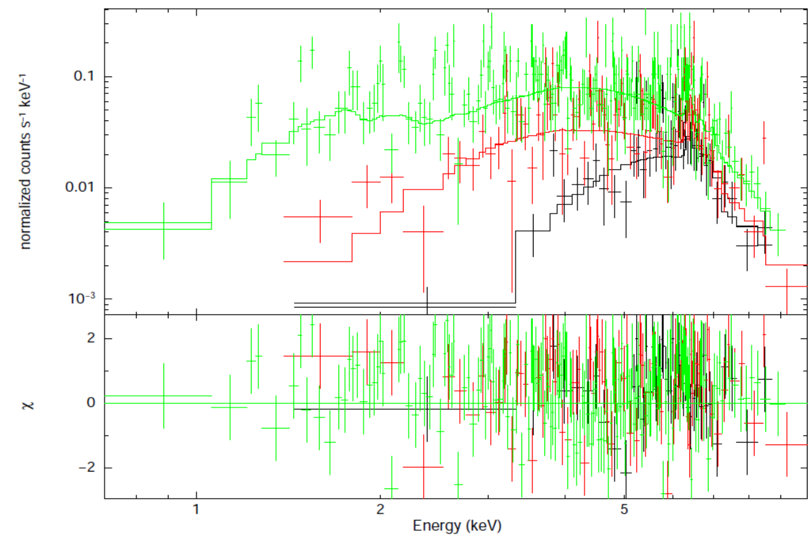


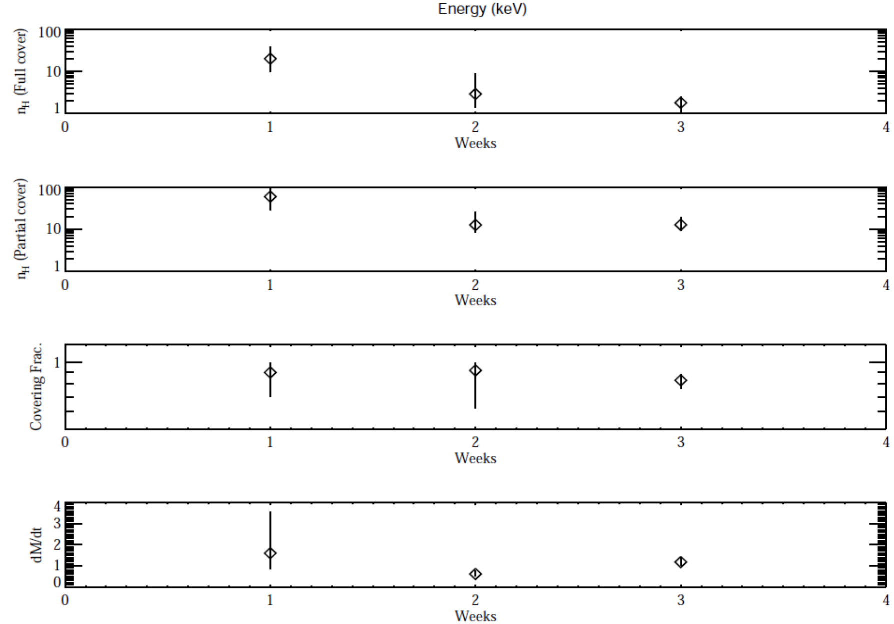
If we model 3 spectra taken over 2 weeks



Allowing only absorption to vary is not enough to match the observed changes.

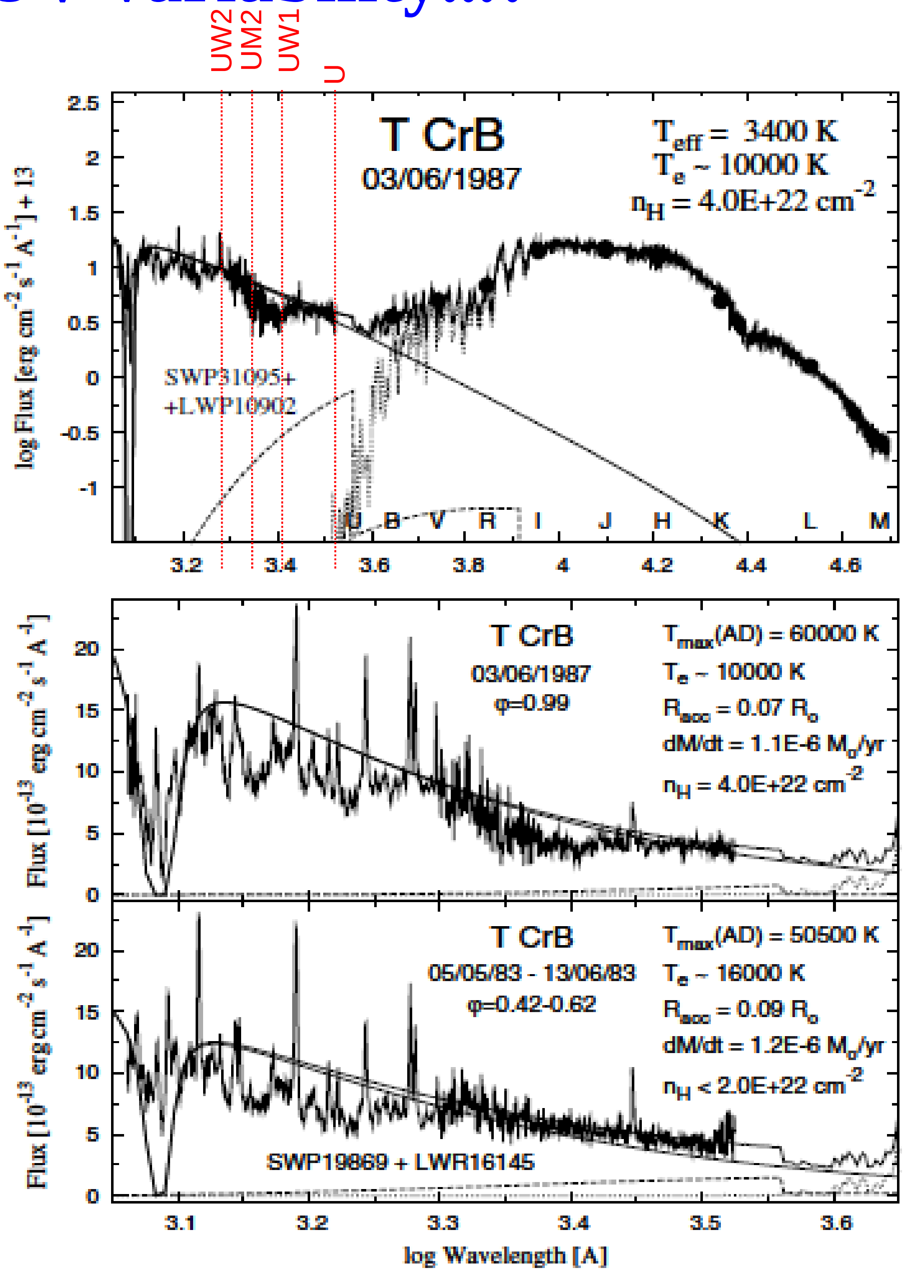
Allowing absorption AND accretion rate to change, we have:





What about the UV variability...?

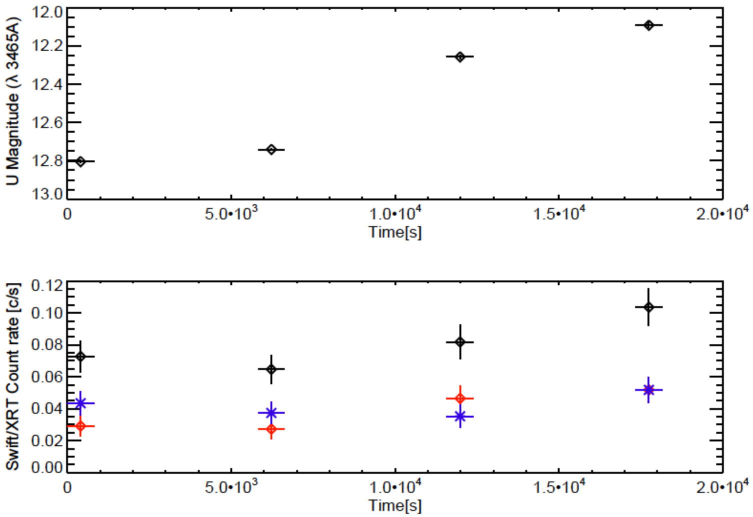
- IF RT Cru is similar to T CrB, then the UV emission could be originated in the accretion disk as the X-rays;
- However, apparently the UV variability is not the same as the X-rays

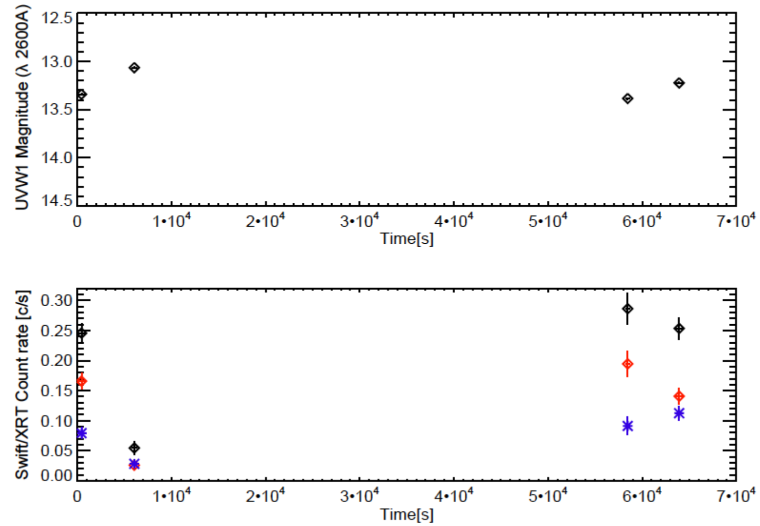


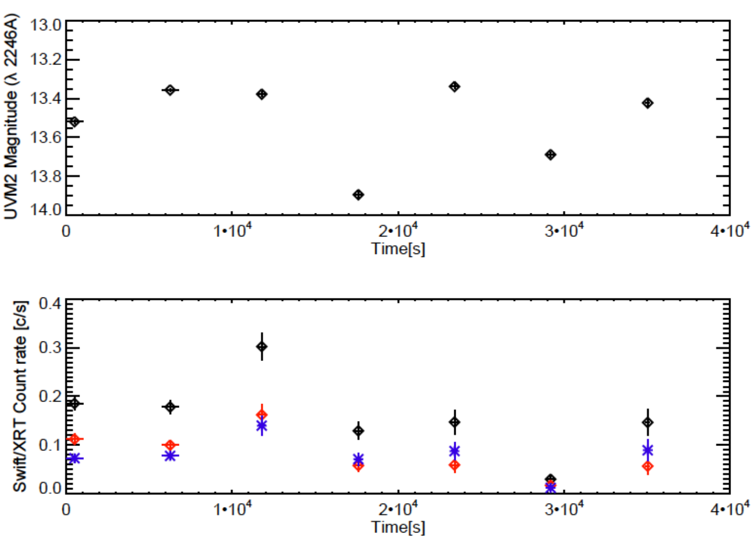
Skopal (2005)

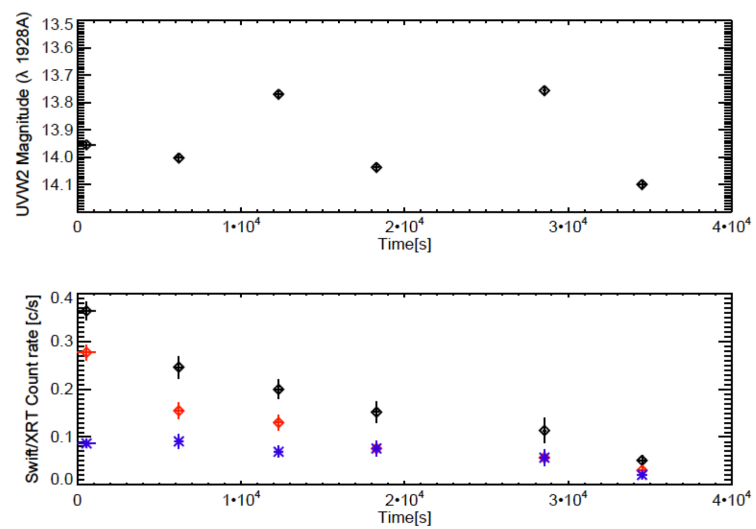
X-rays vs. UV

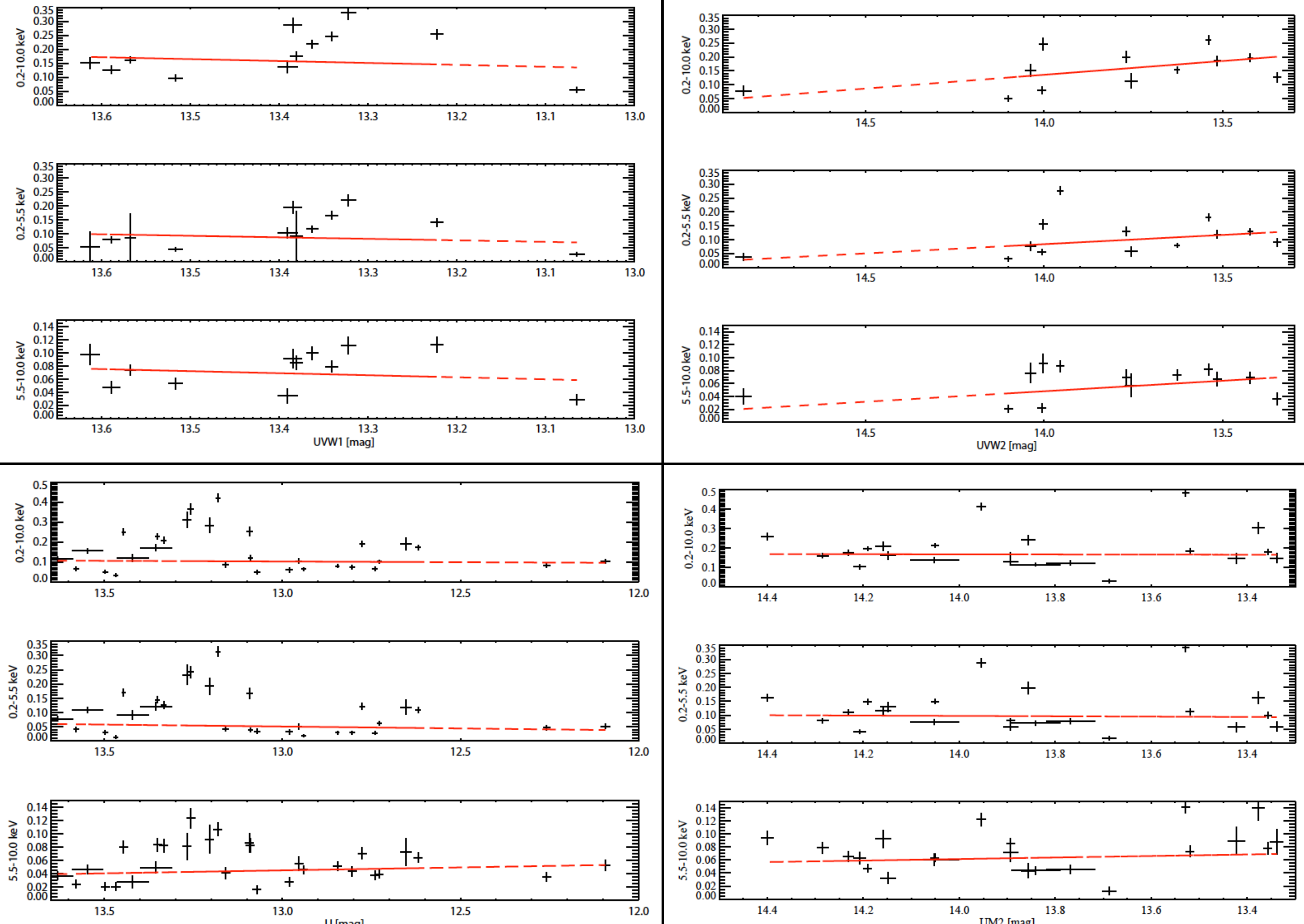
- Are X-rays and UV emission related?










0.2-10.0 keV
0.2-5.5 keV
5.5-10.0 keV
UVW1 [mag]
0.2-10.0 keV
0.2-5.5 keV
5.5-10.0 keV
UVW2 [mag]
0.2-10.0 keV
0.2-5.5 keV
5.5-10.0 keV
U [mag]
0.2-10.0 keV
0.2-5.5 keV
5.5-10.0 keV
UM2 [mag]

Conclusions

- Symbiotics are not as soft as we thought.
- The hard X-ray emission in these new objects seems to be related with shocks and cooling flows in an accretion disk boundary layer;
- The fact that these objects seems to contain massive white dwarf, and therefore could be SNIa progenitors, deserves more study;
- The short and long term X-ray variability in the prototype of the class, RT Cru, seems to be related with absorption AND accretion rate changes. What are the implication for the mass of the white dwarf?. Also, why we haven't detected any major outburst in RT Cru in the last century?;
- How are these changes originated?. Long term (months to years) could be related with changes in accretion rate due to pulsations in the red giant?, while short term could be originated in the accretion disk?