RS Oph in Quiescence: Why Is It X-ray Faint?

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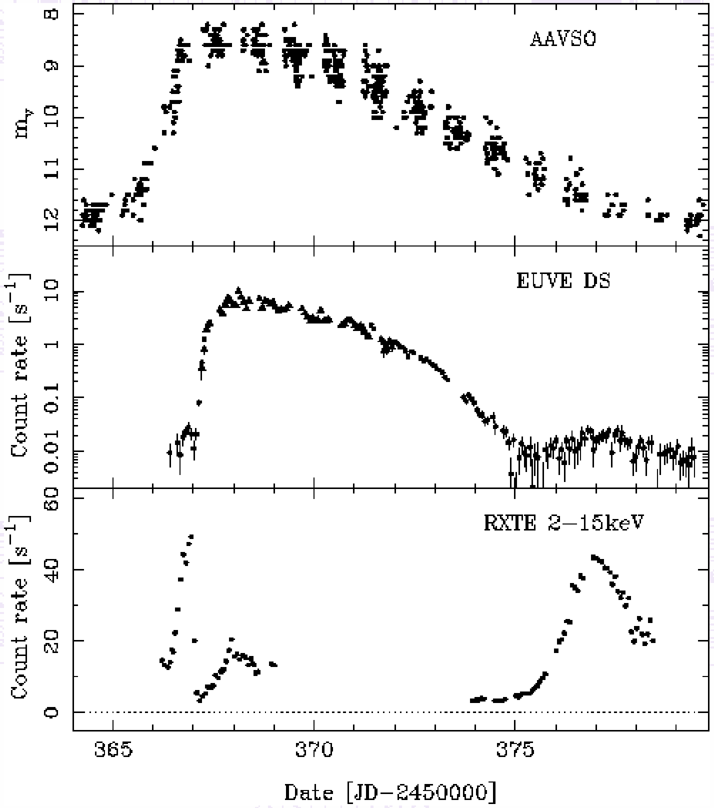
Motivation

- Accretion onto white dwarfs usually results in X-ray emission
  - Highest accretion rate: SSS (steady vs. runaway)
  - High accretion rate: soft X-ray/EUV from optically thick boundary layer + hard (optically thin) X-rays
  - Low accretion rate: hard X-rays from optically thin boundary layer
- The recurrent nova, T CrB, is hard X-ray bright
- Can we learn about the accretion rate etc. in quiescent RNe through X-ray observations?

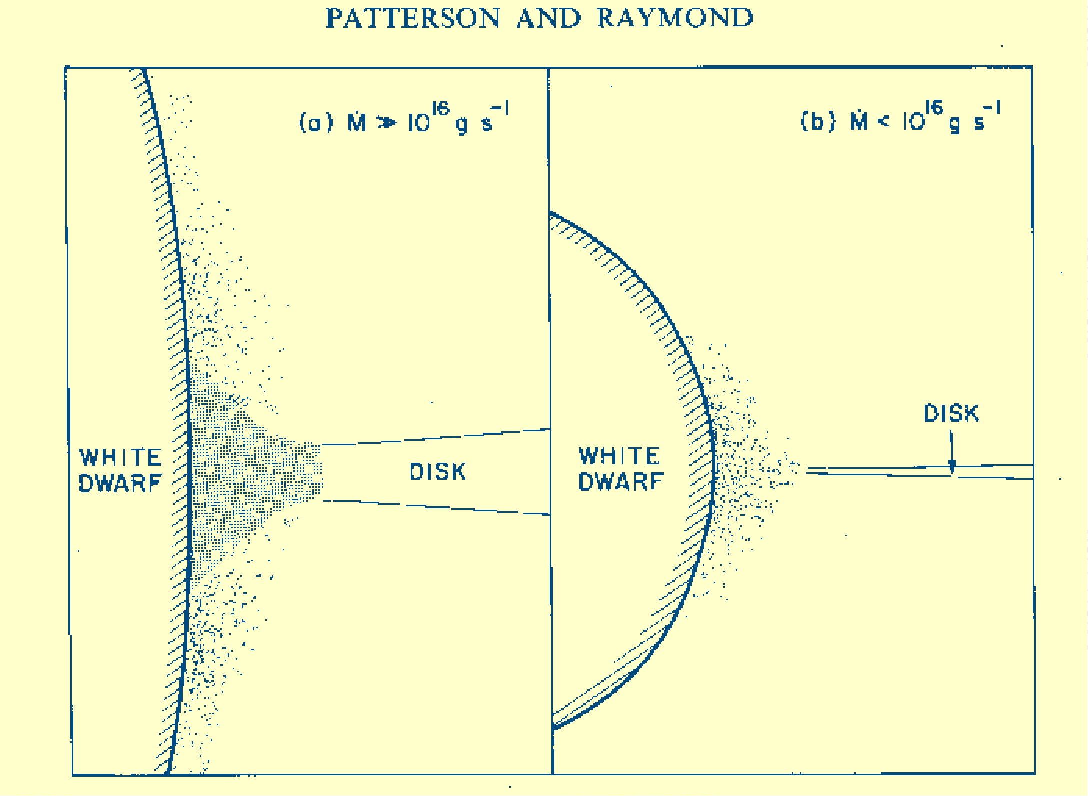
Boundary Layers: Thick & Thin

Two states of the boundary layer are best illustrated by the multi-wavelength observations of the dwarf nova, SS Cyg:

- In quiescence, hard X-ray bright
- During the heart of the outburst, hard X-rays are suppressed (but present), with a strong soft X-ray component



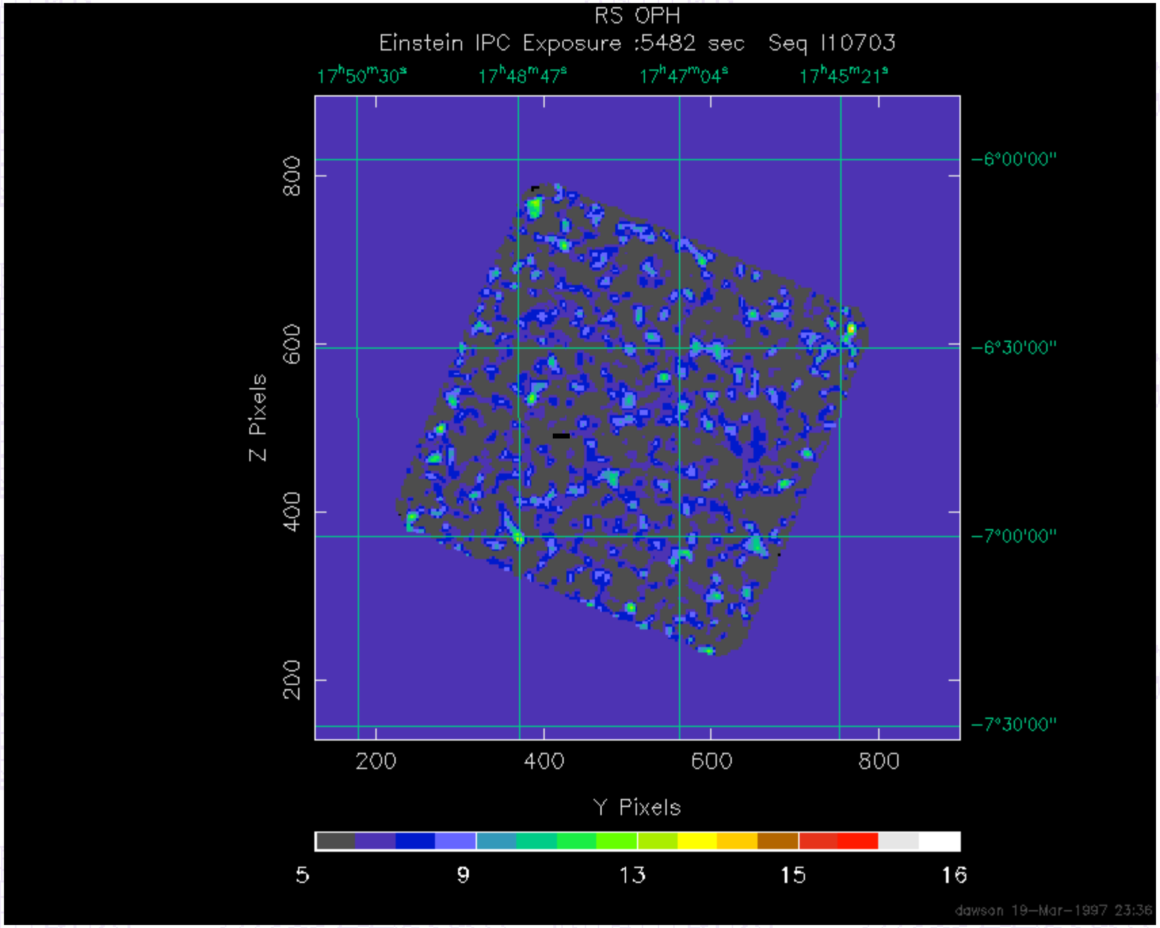
Interpretation Framework



X-ray emission from non-magnetic CVs are interpreted in the Patterson & Raymond framework

Empirical value for optically thin to thick transition is about 10^{16} g s^{-1} or 1.5×10^{-10} M_O yr^{-1}

Recap (1): Einstein Observations



2 IPC Obs.

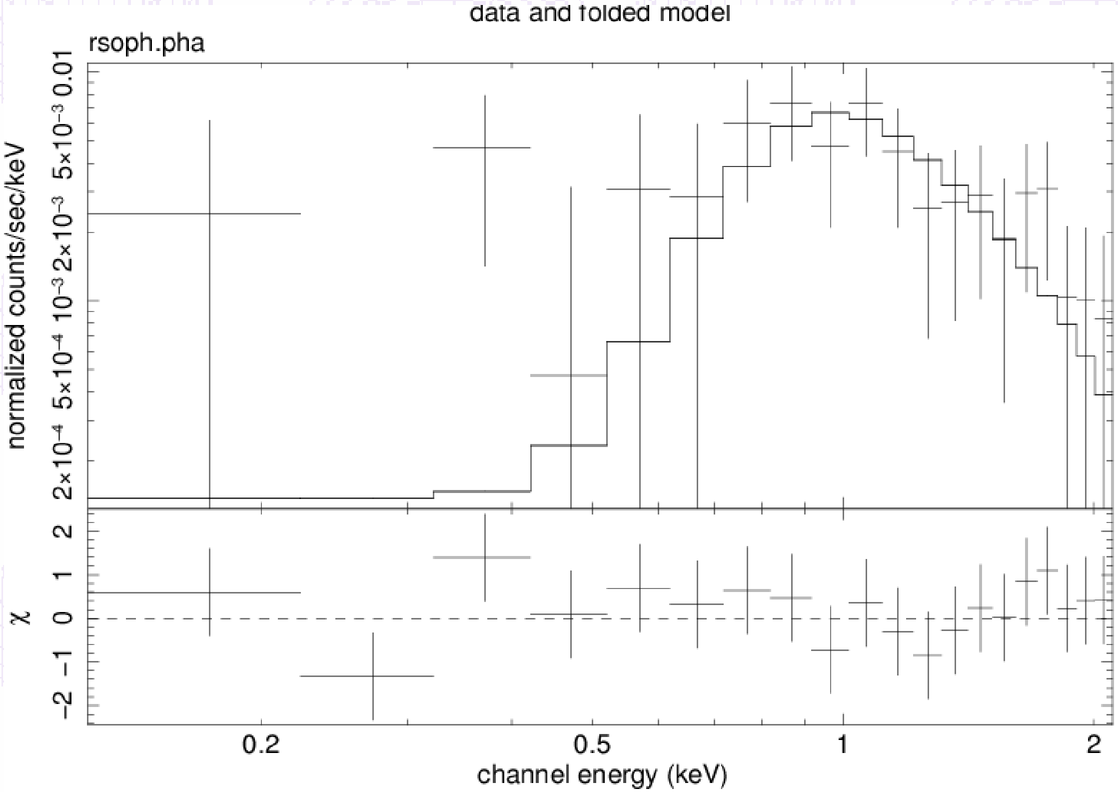
1979 Sep, 1.7 ksec

1981 Apr, 5.5 ksec (image shown)

Not detected in either obs.

Recap(2): ROSAT Detections

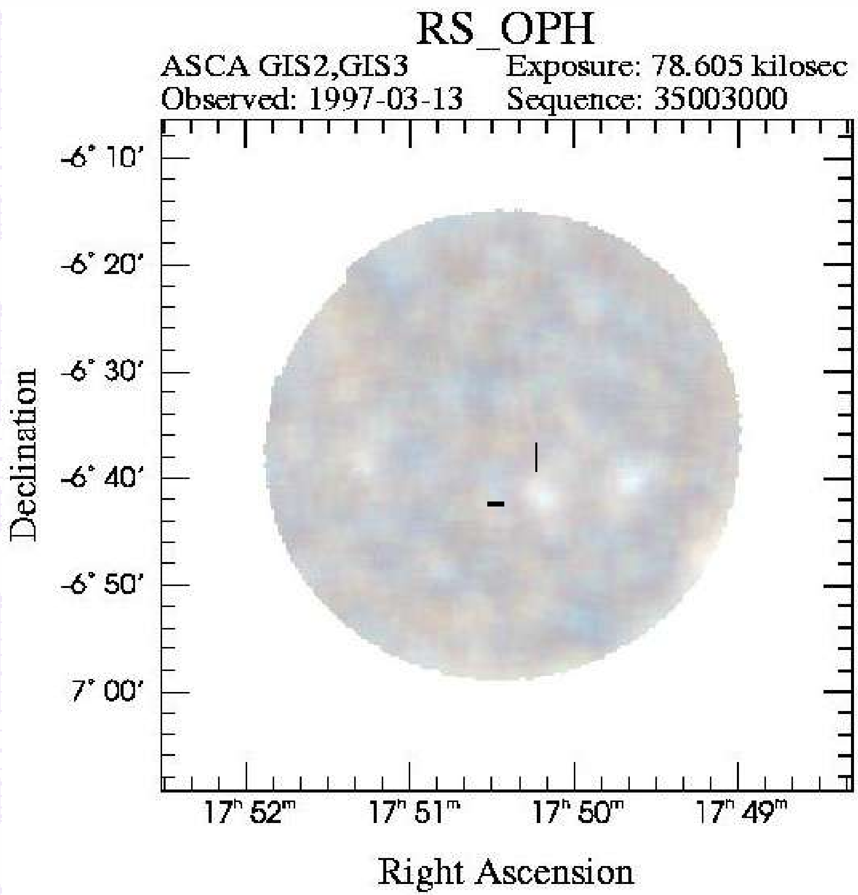
Detections already reported in Orio et al. (2001). Variability from 1991 Mar (0.0035 cps in 5.0 ksec) to 1992 Mar (0.012 cps in 4.7 ksec). Combined spectrum is shown right



More from ROSAT data

- A variety of models can be used to fit the observed spectrum
- One possibility (shown) is Muerset's beta-type: kT~0.6 keV plasma, N_H~9.6x$10^{21}$$cm^{-2}$
  - Inferred luminosity (0.5-2 keV): 1.5x10^{31}ergs s^{-1} (absorbed) or 1.8x10^{32}ergs s^{-1} (unabsorbed)
  - Parameters are similar to those of several beta-type symbiotics (RX Pup, HM Sge, V1016 Cyg, ...)
- Back-predicted Einstine IPC count rate: 2.4x10^{-3}cts s^{-1} or 13 cts in 5.5 ksec: consistent with the non-detection

ASCA Observation



RS Oph was observed for ~40 ksec with ASCA in 1997 March

With the GIS, we obtain 1.3+/-0.4 x 10^{-3} cts s^{-1} (0.7-2 keV) and 1.2+/-0.8 x 10^{-3} cts s^{-1} (2-10 keV)

More numbers from ASCA

- Similarly, RS Oph was detected with the SIS in the soft band but not in the hard
- The ROSAT spectrum is equivalent to ~1.8×10^{-3} cts s^{-1} below 2 keV with GIS, about the same level as observed
- In the 2-10 keV luminosity range, 2×10^{-3} cts s^{-1} with GIS corresponds to 3×10^{31}-1×10^{32} ergs s^{-1} at d=1.6 kpc depending on N_H
- In comparison, T CrB in quiescence is at about 1-2 x 10^{33} ergs s^{-1}

Accretion rate in RS Oph

- The 20 year recurrence period implies a high mass white dwarf accreting at a high rate (1.25 $M_o/5x10^{-8} M_o yr^{-1}$ or $1.4/1x10^{-8}$)
  - Accretion luminosity should be of order $3x10^{35}$-$1x10^{36}$ ergs s^{-1}
- If so, a small fraction is seen in soft X-rays and the upper limit for the hard X-rays is also a small fraction
- The “missing X-ray luminosity problem” is severe - more extreme than in CVs

Other Systems

- T CrB is hard X-ray bright
  - Still a small fraction of the accretion luminosity
  - What is the strong intrinsic absorber?
  - RT Cru and CD -57 3057 apparently similar
- Steeghs has a 50 ksec XMM observation of T Pyx (proprietary)
- No imaging observations of other RNe above 2 keV exist (?)

How to suppress X-rays

- Spin - but a high mass white dwarf requires very fast (P<10 s) spin to reduce luminosity
- Absorption:
  - May work for soft component (but can see SS)
  - Hard component is near-impossible to hide, suggests RS Oph is an extremely inefficient hard X-ray emitter
- Radiation pressure and Compton cooling?!?
  - Possibility explored ~25 years ago but not thought to be important in CVs ($1.4M_O$ and high Mdot required)
  - Might work in systems like RS Oph

Summary

T CrB is hard X-ray bright, whereas RS Oph in quiescence is hard X-ray faint - I leave you with a series of questions

- Can we rule out or prove fast (near break-up) rotation in RS Oph? (Potential implications?)
- Can RS Oph be in Compton degradation regime?
- What is the origin of soft X-rays in RS Oph?
- Are RT Cru and CD -57 3057 unrecognized RNe?
- Are other RNe T CrB-like or RS Oph-like?