Reflections On, and In, Suzaku Observations of Cataclysmic Variables

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CVs and Friends in BAT survey

Intermediate Polars (20):
V709 Cas, 1RXS J005528.0+461143, XY Ari, GK Per, TV Col, TX Col, V405 Aur, BG CMi, Swift J0732.5-1331, PQ Gem, EI UMa, YY Dra, EX Hya, NY Lup, V2400 Oph, IGR J17303-0601, V1223 Sgr, RX J2133.7+5107, FO Aqr, AO Psc

Polars (4):
BY Cam, V1432 Aql, 1RXS J145341.1-552146, 1RXS J231920.9+261525

Dwarf Nova (1):
SS Cyg

CV/IP Candidates (3):
Swift J052522.48+241331.8, 1RXS J122758.8-485343, 1RXS J171935.6-410054

Symbiotic Stars (4):
CD-57 3057, RT Cru, T CrB, CH Cyg

These are accreting white dwarf binaries in the BAT 22 month catalog observed with Suzaku or approved for a Suzaku observation

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Suzaku Science after Three Years
Accretion onto White Dwarfs

The gravitational potential of a white dwarf is deep enough to shock-heat the plasma that strikes its surface to $kT \sim 10-50$ keV, depending on the white dwarf mass. They cool by emitting Mekal/APEC type optically thin thermal plasma emission.

The BAT sample is dominated by magnetic CVs and high Mwd systems.

Two cases:
- Magnetic systems - free fall, strong shock, higher $kT_{\text{max}}$;
- Non-magnetic systems - Keplerian, weaker shock, hence lower $kT_{\text{max}}$. 
Non-BAT CVs

• Probable detection of non-thermal hard X-rays in the propellar system, AE Aqr
• First detection of a partial X-ray eclipse in a dwarf nova system, V893 Sco
• Study of dwarf nova X-ray luminosity function using the Thorstensen sample of systems with parallactic distance determinations (Byckling et al. in preparation)
SS Cyg (Mwd~1.1Mo)

(a) Quiescence

![Graph showing energy spectra for SS Cyg with lines for different energy channels and elements marked with their positions on the energy axis.](image)

- **Counts cm$^{-2}$ s$^{-1}$ keV$^{-1}$**
- **Energy (keV)**
- **Elements: C, N, O, Ne, Mg, Si, S, Ar, Ca, Fe**
- **Legend:**
  - FI–CCD
  - BI–CCD
  - HXD
Probable Geometry

White Dwarf

Reflection

Plasma emission

Reflection

Disk

Thin thermal plasma

$R_{WD}$

$0.12R_{WD}$
In Ishida et al., we used this basic combination to derive the elemental abundances and reflection fraction to infer the boundary layer geometry.
More massive WDs

The graph shows the energy spectrum (keV) normalized counts against energy (keV) for RT Cru. The data points are represented in red and black for different conditions or phases. The lower panel displays the deviation of the observed data from the model, with the green line indicating the best fit. The x-axis represents the energy in keV, while the y-axis shows the normalized counts s$^{-1}$ keV$^{-1}$. The specific details of the analysis are not provided in the text.
Symbiotic Stars

• Symbiotic stars are binaries in which a white dwarf is accreting from an M giant, rather than an M dwarf (which would make it a CV)

• 4 (and now, possibly 5) symbiotic stars have been detected in the BAT survey

• No indications in X-ray or optical data that these white dwarfs are magnetic

• Likely reason for them showing up in the BAT survey: really massive white dwarfs, 1.35 $M_\odot$ and above!
Reflections in IPs

RX J2133
Too Much Reflection?

The fit had rel_refl=4.62! This often happens with MKCFLOW intrinsic model with partial covering absorber model.
Complex Absorber

Even a double or triple partial covering absorber model is not realistic - a continuous distribution of Nh is expected from this geometry.
PWAB model to the rescue

Done & Magdziarz have coded an approximation of this into the XSPEC pwab model --- with parameters typical of IPs, this makes the 0.5-10 keV continuum much harder than the intrinsic emission.

Pcfabs model is a poor approximation which potentially leads to wrong rel_refl (as well as wrong kTmax)
Recent experimentation using pwab with reflect suggests a good fit is possible with rel_refl~1.0, consistent with the 6.4 keV spectrum.
Breaking the Degeneracy

In addition to the 6.4 keV line, the spin modulation can be used to break the degeneracy.

E<4 keV: spin modulation due to variable absorption

E>6 keV: spin modulation due to variable cosi of the reflection

Of the current generation of X-ray satellites, only Suzaku can do such a study (but Astro-H would be even better)