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Simultaneous Chandra/Swift Observations of the RT Cru Symbiotic System

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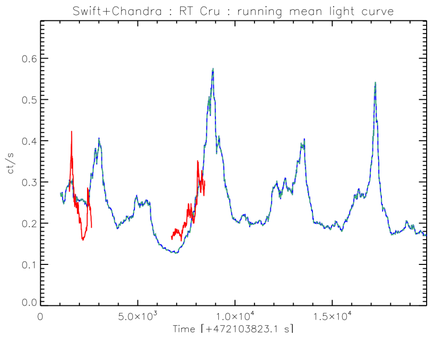
The γ-type hard X-ray symbiotic system RT Cru (WD+M5 III) was observed simultaneously by the Chandra/HRC-I and Swift/XRT in Dec 2012. The observations were carried out as part of a program to calibrate the Chandra PSF.

Symbiotic systems are an important group of interacting binaries in which a WD accretes from the wind of a red giant companion (Kenyon 1986, Karovska et al. 2007). They are possibly progenitors of some asymmetric planetary nebulae, and have been invoked as potential progenitors of Type Ia supernova (see e.g., Chugai & Yungelson 2004, Di Stefano et al. 2010).

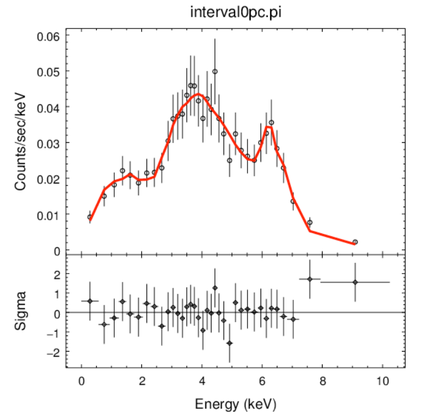
The RT Cru system contains a mass-losing M5 III giant and a high-mass WD (>1.3 $M_\odot$), surrounded by an accretion disk fed by the wind of the red giant (Luna & Sokoloski 2007). It was the first discovered of a new class of symbiotic binaries producing significantly hard X-ray emission (Bird et al. 2007; Kennea et al. 2009).

results & conclusions

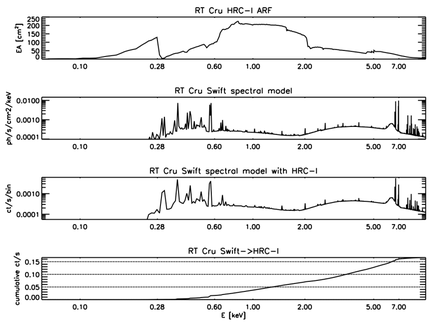
- Highly variable, showing multiple flare-like events separated by ~4 ksec
- Spectrum softens during flares (also seen with 2005 ACIS-S/HETG)
- Swift spectrum underpredicts Chandra rate
- **Strong evidence for a supersoft component** not seen in Swift, but seen with Chandra (needs HRC-S/LETG observation to confirm)
- Chandra source profile shows extension along direction affected by PSF anomaly
- PI distribution significantly different for source photons expected to be affected by PSF anomaly
- HRMA shells 3, 4, and 6 are likely contributors to Chandra PSF artifact



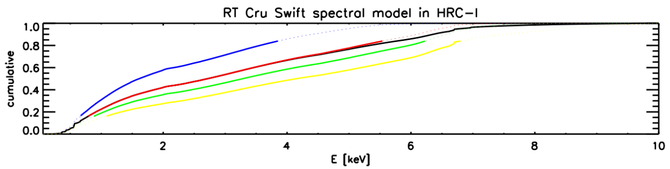
Observed Chandra/HRC-I (blue) and Swift/XRT (red) running mean light curves of RT Cru. The rate is computed for a moving window with a fixed number of photons. The local uncertainty is 3% for Chandra and 10% for Swift. Notice the occasional large flare like events, roughly 4 ksec apart. No periodicity is evident in the data. Swift and Chandra rates are generally correlated, but show some differences in detail.



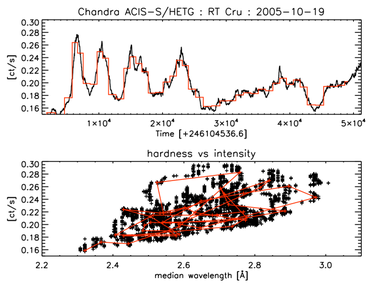
Sherpa/XRT spectrum and best-fit predicted model curve and residuals. The spectral model is a combination of two thermal components, with two separate absorption columns (akin to a partial covering absorption), and a Gaussian model at the Fe K location. The minimum best-fit N_H is significantly lower than the estimated column towards the system, suggesting that previous estimates of the Galactic column density were contaminated by the local column. Because the Swift effective area is small at low energies, if there is a soft component, it cannot be modeled easily.

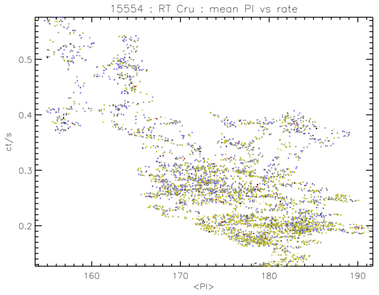


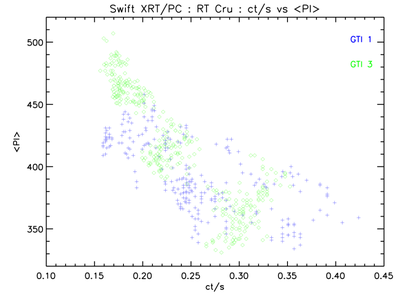
Predicted response in the HRC-I based on the best-fit Swift spectrum. From top to bottom, the panels are: The HRC-I effective area; the best-fit spectral model; the predicted counts spectrum in the HRC-I; and the cumulative counts spectrum. Notice that the nominal spectral model could be supplemented by a soft component that would be observable only with the HRC-I, to account for the difference in the predicted and observed rates.



Cumulative predicted HRC-I count rates due to Chandra Mirror shells 1 (blue), 3 (red), 4 (green), and 6 (yellow). The solid segments denote the central 68% of the spectra. High energy photons are predominantly reflected by Shells 3, 4, and 6.

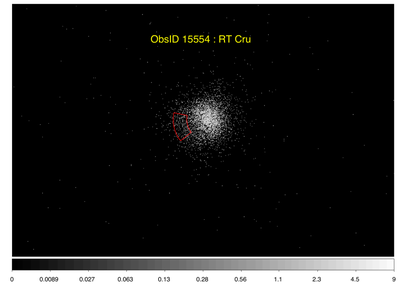






The spectro-temporal variation of RT Cru. The running mean count rates and the running mean PI are plotted below for Chandra/HRC-I (middle) and Swift/XRT (right). There is an unmistakable trend in the spectral hardness with source intensity. As the intensity increases, the spectrum softens. The same behavior is seen in an older Chandra ACIS-S/HETG observation from Oct 2005 (vertical panels on the left): the running mean light curve (upper panel; independent data points are shown as the red histogram) shows the same type of flare-like behavior as seen in the Dec 2012 observations, and the spectral hardness increases as intensity decreases (bottom panel; independent points are shown connected by red line segments). Whether this is due to changes in the spectral model, or because of variations in the absorption column is not known. In either case, a significant soft component is expected to be present.

Chandra/HRC-I image of RT Cru. The putative location of the PSF artifact is shown as the red pie-shaped region. A primary motivation for the Chandra observation was to establish which mirror shell causes the artifact.



RT Cru system

IGR J12349-6434, IGR J12349-6433, HV 1245, SWIFT J1234.7-6433, AAVSO 1229-64

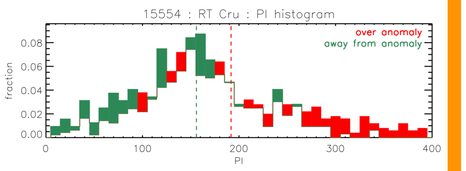
$ICRS_{2000}$	12:34:53.74, -64:33:56.0
(l_{II}, b_{II})	301.1562, -01.7509
distance	1.5-2 kpc
separation	0.5 AU
Gal. N_H	7 10^{21} cm^{-2} (est)

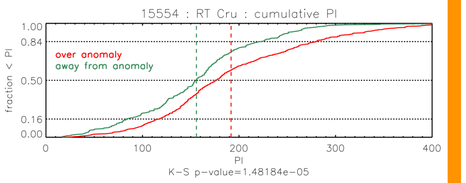
Chandra/HRC-I observation

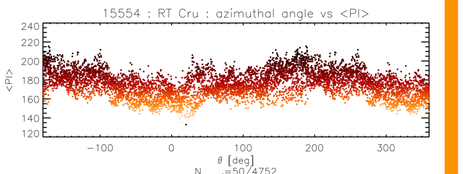
ObsID	15554
Date	2012-12-17
Duration	03:57:03 – 09:48:57
Exposure	19197.8 sec
count rate	0.25 ± 0.004 ct/s

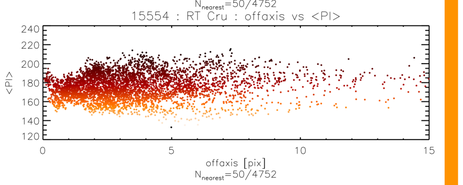
Swift/XRT observation

ObsID	3084007
Duration	04:21:46 – 07:53:55
Exposure	3286.44 sec
count rate	0.32 ± 0.01 ct/s









The HRC-I PI distribution is azimuthally variant. The PI spectrum of events that are nominally affected by the PSF artifact are displaced to higher values compared to those events that are nominally unaffected. The difference is seen in the differential (upprer top) and cumulative (upper bottom) PI distributions, and in the <PI> averaged over the nearest 50 events and shown as functions of the azimuthal angle (lower top) and the distance from the centroid (lower bottom). While the same behavior is seen in other, softer sources, the difference in mean PI is much larger for RT Cru, suggesting that higher energy photons are predominantly reflected into the region affected by the PSF anomaly.

References

- Bird et al. 2007, ApJS 170, 175
- Chugai & Yungelson 2004, Astron.Lett. 30, 65
- Di Stefano et al. 2010, ApJ 719, 474
- Karovska et al. 2007, ApJ 661, 1048
- Kennea et al. 2009, ApJ 701, 1992
- Kenyon 1986, The Symbiotic Stars, Cambridge and New York, Cambridge University Press
- Luna & Sokoloski 2007, ApJ 671, 741

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