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RS Cae – a soft X-ray dominated polar

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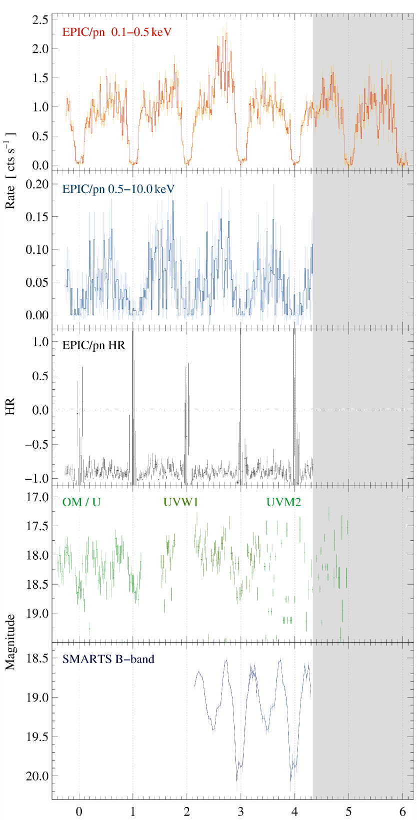
Motivation

In AM Her-type cataclysmic variables, a strong magnetic field of the white-dwarf primary governs the accretion processes, and the accretion stream is funnelled along the field lines towards the magnetic poles of the white dwarf. Their X-ray emission consists of two main components: the harder emission from the cooling accretion column above the white dwarf and the softer emission from the heated accretion region on the white-dwarf surface. On the basis of XMM-Newton and optical observations of selected objects, we investigate the properties and flux contributions of these components.

RS Cae has been part of this campaign due to its high soft X-ray flux that was measured in the ROSAT All-Sky Survey. In 2009, we have obtained XMM-Newton data that cover about five orbital cycles of the binary, and quasi-simultaneous optical light curves.

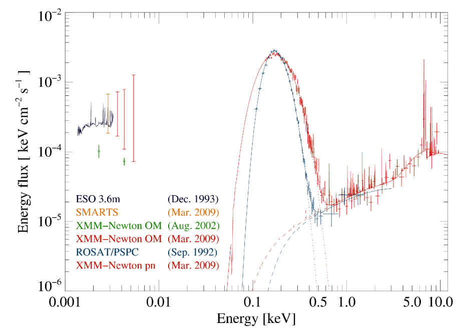
The multi-wavelength light curves



Multi-wavelength light curves of RS Cae, obtained with XMM-Newton and the SMARTS 1.3 m telescope. Almost 11 ksec were affected by high background radiation (grey area). The hardness ratio (middle panel) is defined as HR = $(H-S)/(H+S)$, where H are the counts at energies above and S those below 0.5 keV, respectively. Time bins: 100 s.

The XMM-Newton X-ray light curves (upper panels) show a clear periodicity, that could not be detected in the 1992 ROSAT / PSPC light-curve segments, and remarkably low hardness ratios. The optical and ultraviolet light curves (lower panels) are double-humped. A sharp dip due to a stream-eclipse is visible at all energies and defines phase 0 in the plots. Using the recurrent dips to constrain the binary period, we can confirm the period determination P_{orb}=0.0708 d (102 min) by Burwitz et al. (1996, A&A 305, 507).

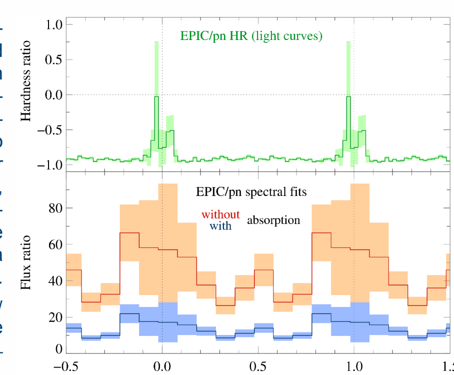
The spectral energy distribution



Spectral energy distribution of RS Cae from 1993 to 2009: Archival data and our 2009 observations in the optical, ultraviolet, and X-ray bands. The photometric data taken by SMARTS and Optical Monitor are given as orbital minimum and maximum.

The ROSAT / PSPC data are over plotted with an absorbed blackbody (kT_{bb} = 25 eV) and a bremsstrahlung component (kT_{br} := 20 keV, Burwitz et al. 1996); the XMM-Newton data with the best-fit XSPEC model. It consists of an absorbed blackbody component and a MEKAL plasma model with partially covering absorption, yielding $N_{H,ISM}=2.0^{+0.8}_{-0.7}\times10^{19}\,\mathrm{cm}^{-2}$, $kT_{bb}=35.7^{+0.7}_{-0.7}\,\mathrm{eV}$, $N_{H,intr}=3.2^{+3.9}_{-1.8}\times10^{22}\,\mathrm{cm}^{-2}$, $kT_{MEKAL}=6.5^{+2.8}_{-2.2}$ keV and solar element abundances.

Phase-resolved soft-to-hard flux ratios



Upper panel: Hardness ratios, derived from the EPIC/pn light curves at energies above and below 0.5 keV, folded to 50 phase bins. Lower panel: Flux ratios, derived from phase-resolved fits to the EPIC/pn spectra (kT_{MEKAL} = 6.5 keV). Red model: TBNEW (BBODY+MEKAL). Blue model: TBNEW (BBODY+ PCFABS(MEKAL)).

The soft-to-hard model flux ratios strongly depend on the choice of the spectral model. When using an intrinsic absorption term, as derived from the fit to the mean non-dip spectrum, the hardness ratios decrease by a factor of about three.

Summary

Our XMM-Newton data of RS Cae are clearly dominated by soft X-ray emission. Spectral fits indicate high bolometric soft-to-hard flux ratios. RS Cae, thus, counts to the sub-group of X-ray soft AM Her-type systems which are believed to show inhomogeneous accretion processes.