Author(s): G. Ramsay, P. Hakala, T. Marsh, G. Nelemans, D. Steeghs, M. Cropper
Article Title: XMM-Newton observations of AM CVn binaries
Year of publication: 2005
Link to published article:
http://dx.doi.org/10.1051/0004-6361:20052950

A&A 440, 675–681 (2005)
DOI: 10.1051/0004-6361:20052950

Astronomy & Astrophysics

XMM-Newton observations of AM CVn binaries

G. Ramsay[1], P. Hakala[2], T. Marsh[3], G. Nelemans[4,5], D. Steeghs[6], and M. Cropper[1]

[1] Mullard Space Science Laboratory, University College London, Holmbury St Mary, Dorking, Surrey RH5 6NT, UK
e-mail: gtbr@mssl.ucl.ac.uk
[2] Observatory, PO Box 14, 00014 University of Helsinki, Finland
[3] Department of Physics, University of Warwick, Coventry CV4 7AL, UK
[4] Institue of Astronomy, University of Cambridge, Madingley Road, Cambridge CB3 0HA, UK
[5] Department of Astrophysics, Radboud University of Nijmegen, PO Box 9010, 6500 Nijmegen, The Netherlands
[6] Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS-67, Cambridge, MA 02138, USA

Received 28 February 2005 / Accepted 26 May 2005

Abstract. We present the results of *XMM-Newton* observations of four AM CVn systems – AM CVn, CR Boo, HP Lib and GP Com. Their light curves show very different characteristics. The X-ray light curves show no coherent pulsations, suggesting the accreting white dwarfs have relatively low magnetic field strengths. Their spectra were best modelled using a multi-temperature emission model and a strong UV component. We find that CR Boo and HP Lib have X-ray spectra with abundances consistent with relatively low temperature CNO processed material, while AM CVn and GP Com show an enhancement of nitrogen. A large fraction of the accretion luminosity is emitted in the UV. We determine accretion luminosities of $\sim 1.6 \times 10^{33}$ erg s^{-1} and 1.7×10^{31} erg s^{-1} for AM CVn and GP Com respectively. Comparing the implied mass transfer rates with that derived using model fits to optical and UV spectra, we find evidence that in the case of AM CVn, we do not detect a significant proportion of the accretion energy. This missing component could be lost in the form of a wind.

Key words. accretion, accretion disks – stars: binaries: general – stars: novae: cataclysmic variables – X-rays: binaries – stars: individual: AM CVn, HP Lib, CR Boo, GP Com

1. Introduction

Most Cataclysmic Variables (CVs) consist of a white dwarf accreting material from a main sequence secondary star through Roche lobe overflow. However, in some CVs (the AM CVn stars) the mass-donating star is hydrogen deficient – either a helium star or a white dwarf (see Warner 1995, for a review). Their optical spectra display no hydrogen features but instead are dominated by helium lines. Since these short orbital period systems are very compact, they are expected to be strong sources of gravitational radiation.

Currently there are ∼13 such systems known, with orbital periods ranging from 5−65 min. The longer period systems, such as GP Com and CE 315, are expected to have lower mass transfer rates than the shorter period systems. The nature of the two shortest period systems, RX J0806+15 (a period of 5.4 min) and RX J1914+24 (9.5 min), remain the subject of some controversy (e.g. Nelemans 2004), but do not show evidence for an accretion disc which is typically seen in other AM CVn systems.

AM CVn stars have been little studied in X-rays. In the *Rosat* all-sky survey only 3 were detected (Ulla 1995). Even for those sources, there is a wide difference in the X-ray to optical ratios. In the UV band at least some systems have been found to be bright (e.g. van Teeseling et al. 1996). *XMM-Newton* with its large effective area X-ray telescopes and its optical/UV telescope, is therefore an ideal satellite with which to obtain multi-wavelength observations of these systems. This paper presents the results of *XMM-Newton* observations of 4 AM CVn systems: AM CVn, HP Lib, CR Boo and GP Com. We relate their X-ray and UV properties to the longer period, hydrogen accreting CVs.

2. Observations

XMM-Newton has 3 broad-band X-ray detectors with medium energy resolution and also a 30 cm optical/UV telescope (the Optical Monitor, OM: Mason et al. 2001). The X-ray instruments contain imaging detectors covering the energy range 0.15−10 keV. Currently the EPIC pn detector (Strüder et al. 2001) is better calibrated at lower energies compared to the EPIC MOS detector (Turner et al. 2001). Two high resolution grating spectrometers (the RGS) are also on board. However, apart from GP Com (whose RGS spectra are discussed in Strohmayer 2004) the sources are too faint to obtain useful spectra. The observation log is shown in Table 1 where we show the mean X-ray and UV count rates for each source.

The data were processed using the *XMM-Newton Science Analysis Software* (SAS) v6.0 and analysed in a similar manner to that in Ramsay et al. (2005). For GP Com, we used the

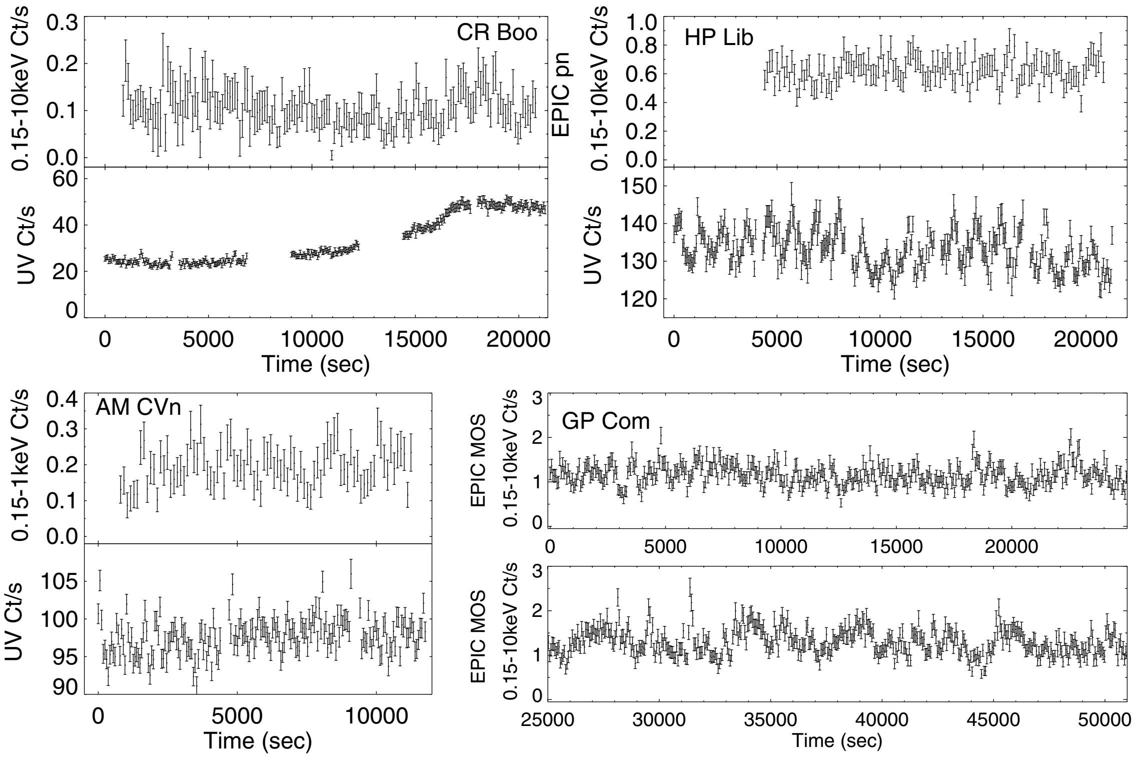

Fig. 1. The X-ray and UV light curves for our sample of AM CVn systems. In the case of GP Com no fast mode UV data was obtained. The OM data has time bins of 60 s, the X-ray data of CR Boo, HP Lib and AM CVn 120 s and GP Com 60 s.

Table 1. The observation log for the sources discussed in this paper. The exposure time is that of the EPIC pn detector. The count rate refers to the mean count rate in the EPIC pn detector (0.15−10 keV) and the *UVW*1 filter (2400−3400 Å). The first observation of AM CVn was affected by high solar particle background.

Source	Date	Exp (ks)	EPIC Ct/s	UV Ct/s
AM CVn	2003-05-23	10.4		
AM CVn	2003-11-24	10.5	0.20	95
CR Boo	2003-12-28	20.0	0.12	35
HP Lib	2004-01-28	20.0	0.65	130
GP Com	2001-01-03	51.2	2.4	12.1

EPIC MOS data since the EPIC pn data were moderately piled up. With the exception of GP Com, each target was observed in the OM using the fast mode and *UVW*1 filter: this has an effective wavelength of 2910 Å and range of 2400−3400 Å. The fast mode data were analysed using the SAS task `omfchain`. GP Com was observed in the OM in full mode and the *V*, *B*, *U*, *UVW*1 and *UVW*2 filters (effective wavelength 2120 Å).

3. Light curves

The X-ray and UV light curves for each source are shown in Fig. 1. In the UV, AM CVn shows little obvious coherent modulation, while HP Lib shows the presence of a clear periodic signal. In contrast, CR Boo shows a large variation over the course of the observation, increasing from ~25 ct/s to ~50 ct/s. The timescale is longer than the 1492 s period reported by Provencal et al. (1997) but much shorter than the 46 day "long" super-cycle reported by Kato et al. (2000). The X-ray light curves do not show strong modulations such as that seen in the UV light curve of HP Lib.

A simple analysis of the X-ray light curves shown in Fig. 1 using the Lomb Scargle algorithm or a DFT produces many peaks in the corresponding power spectrum. However, red noise can lead to the appearance of peaks in the power spectra which can be mistaken for coherent modulation. We use the method of Hakala et al. (2004) to determine the significance of peaks in power spectra.

We performed this analysis on the X-ray and UV data. We show the power spectra of the X-ray light curves in Fig. 2. In X-rays, the spectra of HP Lib shows no peaks above the 99 percent ($=2.6\sigma$) confidence interval. AM CVn has two peaks above this confidence level, at ~1631 s and 338 s, while CR Boo has two, at 742 s and one at 15 124 s. GP Com has 4 peaks which are just above the 99 percent confidence level: at 372 s, 682 s, 2271 s and 3951 s. For all of these peaks, none are related to the known periods for these systems. Further, the known periods in the systems do not correspond to significant peaks in their power spectra. In summary, although there are some peaks which are moderately significant (i.e. above the 99 percent level), we do not consider them to be strongly significant and therefore there is no strong evidence for coherent modulation in the X-ray light curves.

The UV data of HP Lib shows an obvious modulation on a period of 1117 s. This is similar to the period of the super-hump reported by Patterson et al. (2002) which varied

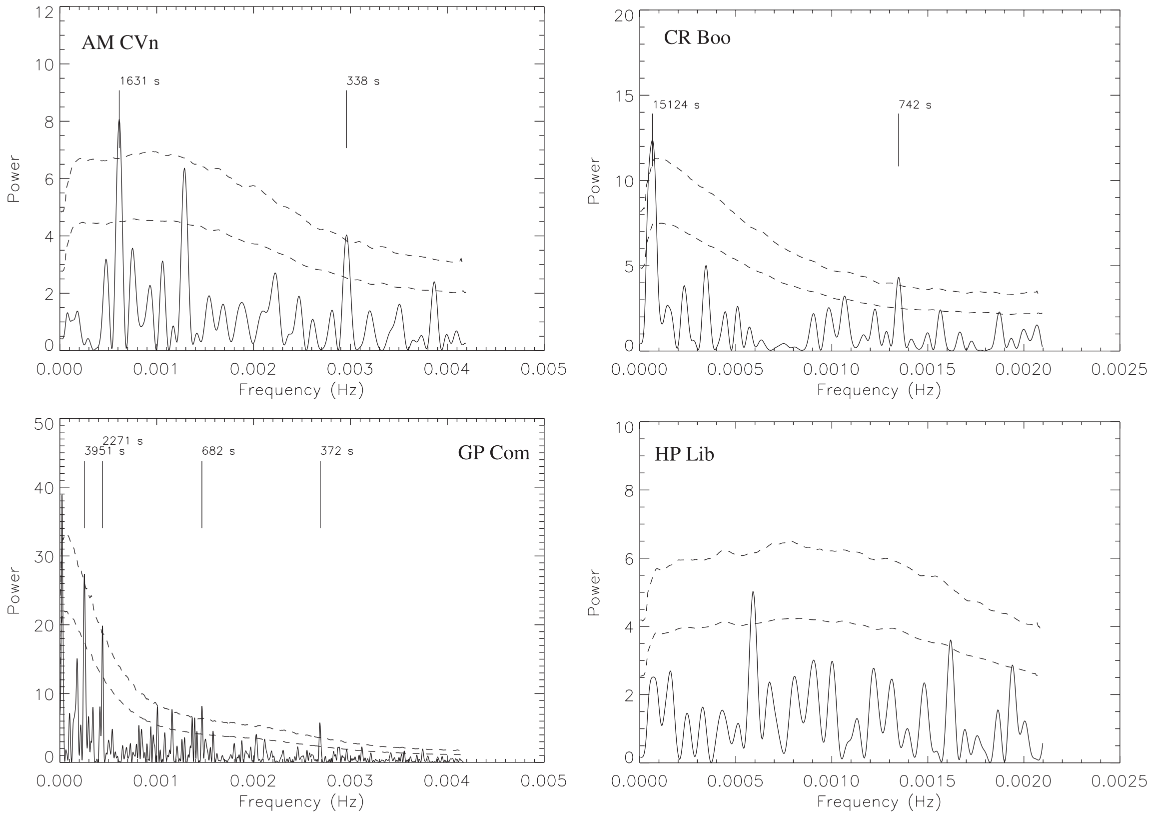

Fig. 2. The power spectra for the X-ray light curves of AM CVn, CR Boo, GP Com and HP Lib, together with the 95 and 99 percent significance intervals based on our red noise analysis.

between 1118.89−1119.14 s in their observations. The power spectrum also shows a period near 560 s which appears to be a harmonic of the main peak (Fig. 3). The AM CVn data shows 3 periods above the 99 percent confidence level: 996 s, 529 s and 332 s. We estimate the error on the longest period to be 11 s: the 996 s period is therefore not significantly different to the strongest period (1014 ± 2 s) detected in the UV by Solheim et al. (1997) and also the 1011.4 s modulation seen in the optical (Provencal 1995). In the case of CR Boo we fitted a polynomial to remove the trend in the light curve. The peak with greatest significance above the 99 percent confidence interval is a peak at 281 s.

We searched for a correlation between the intensity behaviour in the X-ray and UV energy bands using the method of Hakala et al. (2004). Only HP Lib shows a marginal correlation between these light curves: after we had removed the general trend in the UV light curve, there is a broad peak in the correlation function between −450 to −200 s, implying the X-ray trails the UV light curve. However, the most prominent X-ray peak, which occurs at 11 500 s, coincides in time with the UV peak.

4. Spectra

We show the X-ray spectrum of each of our 4 sources in Fig. 4. We then fitted various absorbed thermal plasma models to the data using XSPEC. With the exception of CR Boo, the fits to an absorbed single temperature thermal plasma model were poor. We then fitted each spectrum using an absorbed multi-temperature thermal plasma model in which the emission measures follow a power-law distribution (cemekl in XSPEC). Apart from CR Boo, which gave a reasonable fit, the fits were also poor; this is similar to the result when we allowed the overall metal abundance to vary (Table 2). We note that the spectra of CR Boo and HP Lib show evidence of Fe Kα emission, indicative of the presence of iron, where as there was no such evidence in the spectra of AM CVn and HP Lib. The strong emission features in GP Com are probably due to NVII (near 0.5 keV) and NeX (near 1 keV). Therefore our X-ray spectral fitting indicates that all our targets have non-solar He, C, N, O abundances. The *XMM-Newton* RGS observations of GP Com also show abundances which are very different to solar values (Strohmayer 2004).

The abundance determinations can be understood as the donor star being the remnant of a hydrogen exhausted stellar core. The high N abundance suggests that the burning occurred at temperatures hot enough for the CN(O) cycle to be the dominant burning process (i.e. $T \gtrsim 1.5 \times 10^7$, Bethe 1939). In that case almost all the C (and at higher temperatures O) is transformed into N (e.g. Caughlan & Fowler 1962).

Using the stellar evolution code of Pols et al. (1995) we determined abundances of He = 3.5, C = 0.04, N = 12.5, O = 0.09 (all relative to solar) for relatively low temperature CNO processed material, as appropriate for relatively low-mass stars. Other elements were fixed at solar (we used cevmkl in XSPEC). Apart from GP Com, all sources gave fits which were significantly improved (Table 2). We then allowed the element

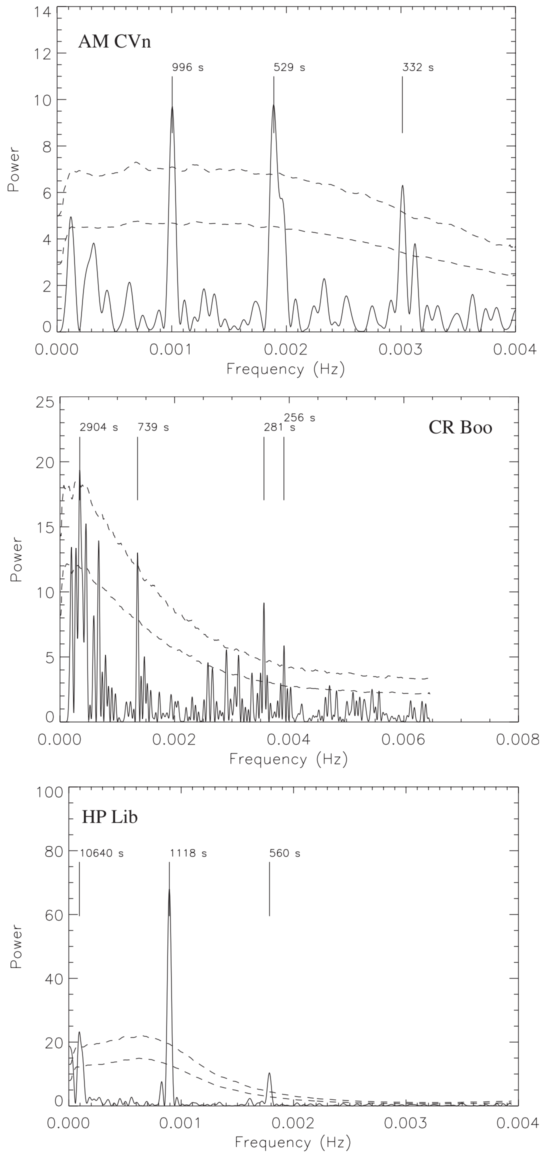

Fig. 3. The power spectra for the UV light curves of AM CVn, CR Boo and HP Lib, together with the 95, 99 percent confidence intervals based on our red noise analysis.

abundances of He, C, N and O to vary and found that the fits to the spectra of GP Com and AM CVn were significantly improved, while HP Lib and CR Boo were not. Both AM CVn and GP Com show a significant enhancement of N compared to that expected from CNO processed material (Table 4).

In the case of GP Com, although the initial fit indicated an enhancement of C relative to CNO, a more complete analysis revealed that it was only the MOS1 spectrum that required C Strohmayer (2004) did not find evidence for the presence of C in his analysis of the same data. To investigate this further, we did the same fitting procedure as Strohmayer: this involved setting the abundances of elements heavier than He to zero then allowing them to vary one by one. If they made no significant improvement they were then fixed at zero. This gave similar results to the previous result with the exception of C which was not found to be required in the fit (consistent with Strohmayer 2004). Using this approach we find best fit abundance values of $O = 0.6^{+1.4}_{-0.2}$, $Ne = 3.4^{+9.6}_{-1.5}$, $S = 0.9^{+3.2}_{-0.3}$, $Fe = 0.1^{+0.6}_{-0.1}$, $Ni = 1.5^{+6.8}_{-1.0}$. We conclude that there is not a significant amount of C in the X-ray spectrum of GP Com.

We show the best fit spectral parameters in Table 4 along with their confidence intervals. We also show the observed X-ray flux in the 0.15−10 keV energy band and the unabsorbed, bolometric X-ray flux inferred for each source. We determine the bolometric X-ray luminosities from recent parallax distance estimates – AM CVn 235 pc (Dahn, referred to in Nelemans et al. 2004); GP Com 70 pc (Thortensen 2003). We find that both these sources have X-ray luminosities $\sim 4 \times 10^{30}$ erg/s.

How do these X-ray luminosities compare with the UV luminosity? We have one UV photometric point for AM CVn, and two for GP Com. This makes it difficult to determine UV fluxes. However, our UV flux measurements (shown in Table 3 and which were determined by taking the count rate to flux conversion appropriate to white dwarfs from the *XMM-Newton* ESA web site) are within a factor of 2 compared to the *IUE* flux measurements (obtained from the *IUE* archive at STScI). We therefore integrated the *IUE* spectra of AM CVn and GP Com from the archive between 1100−3400 Å. Assuming the same distances as before we find UV luminosities of 1.6×10^{33} erg/s and 1.3×10^{31} erg/s for AM CVn and GP Com respectively. While the UV luminosity of GP Com is a factor of 3 greater than its X-ray luminosity, in AM CVn the UV luminosity is nearly 3 orders of magnitude greater than its X-ray luminosity. We discuss this further in Sect. 6.

5. Comparing the properties of AM CVn systems with other CVs

The X-ray luminosities of AM CVn and GP Com are lower than most types of hydrogen accreting CVs, which show $L_X \sim 10^{31-33}$ erg s^{-1}. The diskless AM CVn systems, RX J1914+24 and RX J0806+15, show very different X-ray spectra, showing prominent soft blackbody spectra (Ramsay et al. 2005).

To extend the comparison further we compare the relative flux in soft/hard X-rays with the relative flux in soft X-rays/UV for various varieties of CVs. We determined the flux in the 0.15−0.5 keV and the 2−10 keV band and normalised them to give the flux in erg s^{-1} cm^{-2} Å^{-1}. We corrected the fluxes for the extinction that was determined from the X-ray spectrum for each source individually. We plot the ratio of our AM CVn sample in Fig. 5 in the 0.15−0.5/*UVW*1, 0.15−0.5/2−10 keV plane. We also show the strongly magnetic CVs (the polars) taken from the sample of Ramsay & Cropper (2004) and the non-magnetic CVs taken from the *XMM-Newton* public archive. We find that the soft/hard X-ray ratio of the AM CVn systems are similar to that found for the non-magnetic CVs, while most of the polars show a higher soft/hard ratio since they have a significant soft X-ray component due to re-processing of the hard component. On the other hand, for the AM CVn systems the soft X-ray/UV ratio is very low (apart from GP Com) which indicates that compared to either the non-magnetic and magnetic sample, the AM CVn systems have a strong UV component, or a weak soft X-ray component. In contrast, RX J0806+15 is at an extreme end of the

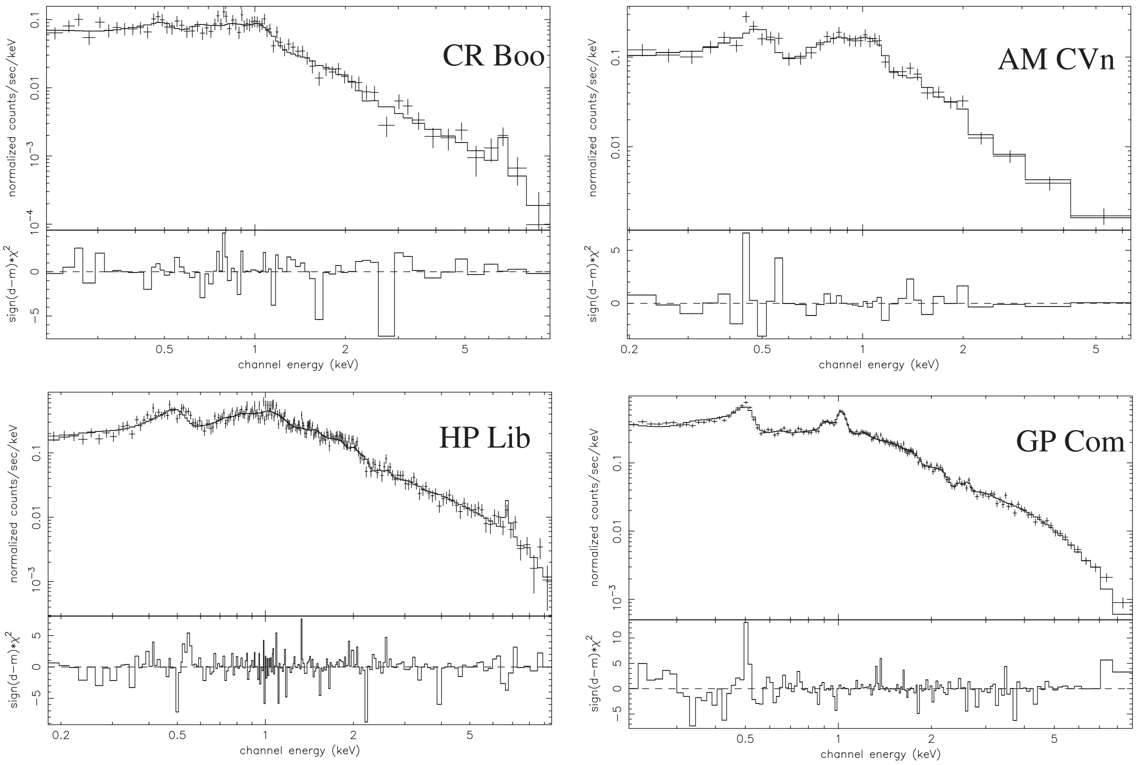

Fig. 4. The EPIC spectra of CR Boo, AM CVn, HP Lib and GP Com together with the best fit models overlayed.

Table 2. The fits (χ^2_ν, d.o.f.) to the *XMM-Newton* EPIC data using various emission models. cemekl: a thermal plasma with power law temperature distribution – a metal abundance of solar ($Z = 1$) and variable abundance are shown; cevmkl – as cemekl but the abundance of each element is allowed to vary – a metal abundance consistent with CNO processed composition, and when allowed to vary. An absorption component was included in each model.

Source	cemekl ($Z = 1$)	cemekl Z var	cevmkl (CNO)	cevmkl Z var
HP Lib	1.97 (213)	1.60 (212)	1.18 (212)	1.16 (213)
CR Boo	1.15 (72)	1.15 (71)	1.05 (72)	1.05 (65)
GP Com	14.9 (160)	6.35 (159)	7.77 (160)	1.32 (153)
AM CVn	2.54 (35)	2.20 (34)	1.31 (35)	1.02 (34)

diagram, which is expected for a strong soft X-ray source with both weak UV and hard X-ray emission. (The interstellar extinction to RX J1914+24 is so high that the UV emission is not detectable).

6. Discussion

6.1. Light curves

The X-ray and UV light curves of the 4 systems in our sample are very different. While the sources show variability in their X-ray intensity, there is only marginal evidence for coherent modulation. This is similar to that of non-magnetic CVs, most of which show no evidence for significant X-ray modulations at periods shorter than a few hours (e.g. Baskill et al. 2005).

Table 3. The inferred flux in the OM *UVW*1 filter assuming a conversion from count rate to flux applicable to white dwarfs.

Source	UV Flux (erg s^{-1} cm^{-2} Å^{-1})
AM CVn	4.18×10^{-14}
CR Boo	1.54×10^{-14}
HP Lib	5.72×10^{-14}
GP Com	5.32×10^{-15}

Those few non-magnetic CVs which *have* shown evidence, e.g. OY Car (Ramsay et al. 2001), have been associated with the spin period of the white dwarf. This implies that the accretion flow is controlled by the magnetic field of the white dwarf as it nears the white dwarf suggesting a significant magnetic field strength (of order 10^5 G). Our observations suggest that the accreting white dwarfs in the disc accreting AM CVn systems presented here do not have significant magnetic fields.

In contrast, the UV observations of our sample shows remarkably heterogeneous behaviour. CR Boo shows a significant increase in intensity over the 5.5 h observation – the cause of this variation is not clear. In HP Lib, there is a strong coherent modulation. It is similar to that of the UV modulation in the intermediate polar FO Aqr (Evans et al. 2004). In these systems the accreting white dwarfs disrupts the formation of a disc close to the white dwarf and accretes via a disc-fed accretion “curtain”. However, unlike FO Aqr, HP Lib shows no strong evidence for a coherent modulation in X-rays. In AM CVn we detect a period at 996 s: this period is not significantly different previously reported periods at 1011.4 and 1014 s.

Table 4. The spectral parameters derived from fitting an absorbed multi-temperature thermal plasma model with variable metal abundance, Z, to the *XMM-Newton* EPIC data. The slope of the power law distribution of temperature, α, and the maximum temperature, $T_{\rm max}$ of the plasma are shown. We show the observed X-ray flux in the 0.15−10 keV band, $F_{\rm x,o}$, the unabsorbed, bolometric X-ray flux, $F_{\rm x,u}$, the bolometric X-ray luminosity, $L_{\rm X}$.

Source	$N_{\rm H}$ $\times 10^{20}$ cm^{-2}	α	$T_{\rm max}$ (keV)	Z (solar)	$F_{\rm x,o}$ erg s^{-1} cm^{-2}	$F_{\rm x,u}$ erg s^{-1} cm^{-2}	$L_{\rm X}$ erg/s
AM CVn	$5.4^{+3.5}_{-2.5}$	$1.05^{+0.42}_{-0.15}$	4.6 ± 1.0	30^{+14}_{-10} (N)	3.72×10^{-13}	6.39×10^{-13}	4.2×10^{30}
CR Boo	$2.4^{+1.4}_{-1.3}$	$1.0^{+0.2}_{-0.4}$	$8.2^{+4.0}_{-2.3}$	14^{+9}_{-7} (N)	2.39×10^{-13}	3.79×10^{-13}	
HP Lib	$13.3^{+4.0}_{-2.4}$	$0.8^{+0.3}_{-0.3}$	$8.4^{+2.4}_{-1.6}$	19^{+10}_{-8} (N)	1.59×10^{-12}	3.10×10^{-12}	
GP Com	$0.0^{+0.1}$	$0.86^{+0.16}_{-0.02}$	8.0 ± 0.7	30^{+60}_{-15} (N)	5.50×10^{-12}	7.76×10^{-12}	4.5×10^{30}

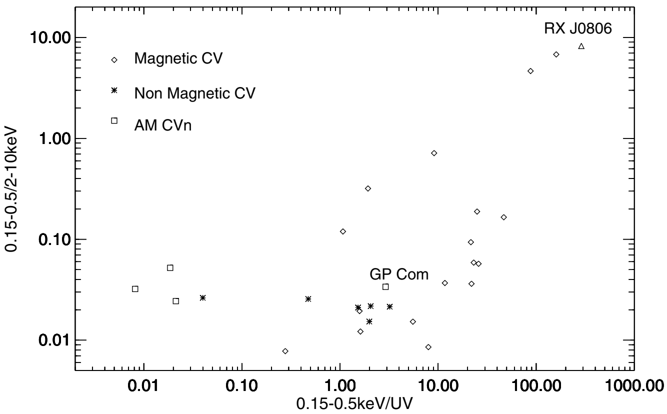

Fig. 5. The colours for the AM CVn systems in this paper; non-magnetic CVs and the strongly magnetic CVs in the 0.15−0.5/2−10 keV, 0.15−0.5/UV plane.

6.2. Accretion rates

We determine the accretion luminosity by simply summing up the X-ray and UV luminosity. In practice some fraction of the UV luminosity will originate from the disc and/or the white dwarf. Further, it is not clear how the lack of hydrogen will affect the optical thickness of the X-ray and UV emitting regions. We therefore find $L_{\rm tot} = 1.6 \times 10^{33}$ erg s^{-1} and 1.7×10^{31} erg s^{-1} for AM CVn and GP Com respectively. We determine the accretion rate from $L_{\rm tot} = GM\dot{M}/R$ (i.e. the sum of the accretion disc emission and the emission from the region close to the accreting object). We therefore obtain $\dot{M} = 1.0 \times 10^{16}$ g/s (=1.6×10^{-10} $M_\odot$/yr) and 1.1×10^{14} g/s (=1.7×10^{-12} $M_\odot$/yr) for AM CVn and GP Com respectively for a 0.6 $M_\odot$ accreting white dwarf. These are lower limits to the accretion rate since we did not include UV emission outside the range 1100−3400 Å (Sect. 4) and we did not include optical emission.

How do the above values compare with other estimates of the accretion rate in these objects? Nasser et al. (2001) and Nagel et al. (2004) modelled optical spectra of several AM CVn systems using NLTE models and both determined an accretion rate of 3×10^{-9} $M_\odot$/yr for AM CVn. This is consistent with theoretical work which has predicted an accretion rate of $1\times10^{-8}-4\times10^{-10}$ $M_\odot$/yr (Deloye et al. 2005). This suggests that for AM CVn, we do not observe a significant proportion of the accretion energy. One possible solution is that the material is lost in the form a wind (Solheim et al. 1997).

6.3. The sources of emission in AM CVn systems

The AM CVn systems in our survey all show X-ray spectra which are best modelled using a multi-temperature emission model and a strong UV component. The systems are not only hydrogen deficient but also show non-solar metalicities. Figure 5 indicates that compared to hydrogen donor CVs, the disk-accreting AM CVn systems (with the exception of the longer period system GP Com) show low soft X-ray/UV colours, but similar soft X-ray/hard X-ray ratios. This implies that the UV component plays a more dominant role in disk accreting AM CVns or that the X-ray component is significantly less prominent than expected.

In non-magnetic CVs, the soft X-ray emission is expected to be dominated by boundary layer emission as opposed to emission from the extended disc. At high mass transfer rates, this boundary layer is optically thick and emits chiefly in the UV regime (e.g. Popham & Narayan 1995), while at low mass transfer rates the optically thin layer can contribute to harder X-ray emission. The lack of hydrogen in AM CVn systems will not only affect the properties of their helium dominated accretion disks, but also their boundary layer. Although it is not obvious as to how this will affect the overall spectrum, it is expected that given the higher mass transfer rates, a strong UV component suggests this optically thick boundary layer picture for the UV/soft X-ray emission also applies to the short period AM CVn systems. This is consistent with observations of hydrogen accreting dwarf novae CVs undergoing an outburst (i.e. high accretion rates), which show an increase in their UV flux and a decrease in soft X-rays (e.g. Wheatley et al. 1996). We also note that the stability of the disc is influenced by the metal abundance of the disc (e.g. Menou et al. 2002).

6.4. The element abundances

Our X-ray spectral fits showed that a good fit was obtained for HP Lib and CR Boo when we assumed a metal abundance consistent with that expected from CNO processed material. In the case of AM CVn a slightly higher abundance of N gave a significantly better fit (99.7 percent significance). In the case of GP Com, the abundance of N and O is enhanced compared to low temperature CNO reprocessed material, with evidence of significant amounts of Ne, S, Fe and Ni (Sect. 4).

How do these results compare with optical results? Marsh et al. (1991) found one oxygen atom for every 50 nitrogen atoms. Taking solar abundance values from Anders & Grevesse (1989) we find a higher number, one in ~6. We determine a ratio of log(N/Fe) = 2.8 compared to >3.5 from Marsh et al. (1991). The X-ray fits were not very sensitive to the abundance of helium.

Some difference can be expected between the optical and X-ray results because of our ignorance of the exact physical conditions in these systems. The optical abundances were based upon single temperature LTE models for atoms of very different excitation and ionisation energy, namely neutral helium and nitrogen. The overall abundance of nitrogen from the optical data is therefore uncertain. It is less obvious that the optical N/Fe ratio should be far wrong given the comparable ionisation energies of NI and FeII. However, it is possible that high optical depths in the NI lines in the LTE model lead to an overestimate of this ratio, assuming that there was in fact some unaccounted-for broadening mechanism which could raise the line strength for a given abundance.

7. Conclusions

We have presented observations of 4 disk accreting AM CVn systems. Their X-ray and UV intensity variations are heterogeneous, with only HP Lib showing a very clear coherent modulation in its UV light curve. Their X-ray spectra are best fitted with highly non-solar abundances, with CR Boo and HP Lib showing abundances consistent with that expected from low temperature CNO reprocessed material. AM CVn and GP Com show an enhancement of nitrogen, while GP Com shows an enhancement of additional elements. By comparing the abundances determined using X-ray, UV and optical methods in detail, it will be possible to gain a better understanding of the underlying physical nature of their emission sites. Moreover, once we have a better understanding of their abundances we can in principal determine the systems evolutionary history. A large fraction of the accretion luminosity is emitted in the UV.

Acknowledgements. This paper is based on observations obtained using *XMM-Newton*, an ESA science mission with instruments and contributions directly funded by ESA Member States and the USA (NASA). P.H. is supported by the Academy of Finland and DS acknowledges a Smithsonian Astrophysical Observatory Clay Fellowship. We thank the referee, Jan-Erik Solheim, for useful comments which helped improve the paper.

References

Anders, E., & Grevesse, N. 1989, Geochim. Cosmochim. Acta, 53, 197
Baskill, D. S., Wheatley, P. J., & Osborne, J. P. 2005, MNRAS, 357, 626
Bethe, H. A. 1939, Phys. Rev., 55, 434
Caughlan, G. R., & Fowler, W. A. 1962, ApJ, 136, 453
Deloye, C. J., Bilstein, L., & Nelemans, G. 2005, ApJ, 624, 934
Evans, P. A., Hellier, C., Ramsay, G., & Cropper, M. 2004, MNRAS, 349, 715
Hakala, P., Ramsay, G., Wheatley, P., Harlaftis, E. T., & Papadimitriou, C. 2004, A&A, 420, 273
Kato, T., Nogami, D., Baba, H., Hanson, G., & Poyner, G. 2000, MNRAS, 315, 140
Marsh, T., Horne, K., & Rosen, S. 1991, MNRAS, 366, 535
Mason K. O., Breeveld, A., Much, R., et al. 2001, A&A, 365, L36
Menou, K., Perna, R., & Hernquist, L. 2002, ApJ, 564, L81
Nagel, T., Dreizler, S., Rauch, T., & Werner, K. 2004, A&A, 428, 109
Nasser, M. R., Solheim, J.-E., & Semionoff, D. A. 2001, A&A, 373, 333
Nelemans, G. 2004, In Proc. The astrophysics of cataclysmic variables and related objects, ed. J. M. Hameury, & J. P. Lasota [arXiv:astro-ph/0409676]
Nelemans, G., Yungelson, L. R., & Portegies Zwart, S. F. 2004, MNRAS, 349, 181
Patterson, J., Fried, R. E., Rea, R., et al. 2002, PASP, 114, 65
Popham, R., & Narayan, R. 1995, ApJ, 442, 337
Pols, O. R., Tout, C. A., Eggleton, P. A, & Han, Z. 1995, MNRAS, 274, 964
Provencal, J. L., Winget, D. E., Nather, R. E., et al. 1995, ApJ, 445, 927
Provencal, J. L., Winget, D. E., Nather, R. E., et al. 1997, ApJ, 480, 383
Ramsay, G., Poole, T., Mason, K., et al. 2001, A&A, 365, L288
Ramsay, G., & Cropper, M. 2004, MNRAS, 347, 497
Ramsay, G., Hakala, P., Wu, K., et al. 2005, MNRAS, 357, 49
Solheim, J. E., Provencal, J. L., & Sion, E. M. 1997, In White dwarfs, Proc. 10th European Workshop on White Dwarfs, ed. J. Isern, M. Hernanz, & E. Gracia-Berro (Dordrecht: Kluwer Academic Publishers), Astro. Space Sci. Lib., 214, 337
Strohmayer, T. E. 2004, ApJ, 608, L53
Strüder, L., Briel, U., Dennerl, K., et al. 2001, 365, L18
Thorstensen, J. R. 2003, AJ, 126, 3017
Turner, M., Abbey, A., Arnaud, M., et al. 2001, A&A, 365, L27
van Teeseling, A., Beuermann, K., & Verbunt, F. 1996, A&A, 315, 467
Ulla, A. 1995, A&A, 301, 469
Warner, B. 1995, Cataclysmic variable stars (Cambridge: Cambridge Univ. Press)
Wheatley, P. J., Verbunt, F., Belloni, T., et al. 1996, A&A, 307, 137