A&A manuscript no.
(will be inserted by hand later)

Your thesaurus codes are:
(02.01.2; 08.02.1; 08.09.2; 08.23.1; 13.25.5)

ASTRONOMY AND ASTROPHYSICS

arXiv:astro-ph/9904012 v1 1 Apr 1999

A BeppoSAX observation of the supersoft source 1E 0035.4-7230

P. Kahabka[1], **A.N. Parmar**[2], **and H.W. Hartmann**[3]

[1] Astronomical Institute and Center for High Energy Astrophysics, University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, The Netherlands
[2] Astrophysics Division, Space Science Department of ESA, ESTEC, P.O. Box 299, 2200 AG Noordwijk, The Netherlands
[3] SRON Laboratory for Space Research, Sorbonnelaan 2, 3584 CA Utrecht, The Netherlands

Received 17 February 1999 / accepted 30 March 1999

Abstract. Results from a 37 ks BeppoSAX Low-Energy Concentrator Spectrometer (LECS) observation of the supersoft source SMC 13 (=1E 0035.4-7230) in the Small Magellanic Cloud are reported. This source has probably the softest spectrum observed so far with BeppoSAX, with no detected counts $\gtrsim$0.5 keV. The BeppoSAX spectrum is fitted either with a blackbody spectrum with an effective temperature kT = 26–58 eV, an LTE white dwarf atmosphere spectrum with kT = 35–50 eV, or a non-LTE white dwarf atmosphere spectrum with kT = 25–32 eV. The bolometric luminosity is not very well constrained, it is $< 8\ 10^{37}$ erg s^{-1} and $< 3\ 10^{37}$ erg s^{-1} for the LTE and the non-LTE spectrum (90% confidence).

We also applied a spectral fit to combined spectra obtained with BeppoSAX LECS and with ROSAT PSPC. We find that a blackbody spectrum with an effective temperature kT=(39–47) eV and a bolometric luminosity of $(0.3-5)\ 10^{37}$ erg s^{-1} fits the data. The data are also fitted with a blackbody with a kT of (50–81) eV, an average C-edge at (0.38–0.47) keV with an optical depth $\tau > 1.1$, and a bolometric luminosity of $(3-8)\ 10^{36}$ erg s^{-1} (90% confidence). We also applied LTE and non-LTE white dwarf atmosphere spectra. The kT derived for the LTE spectrum is (45–49) eV, the bolometric luminosity is $(3-7)\ 10^{36}$ erg s^{-1}, The kT derived for the non-LTE spectrum is (27–29) eV, the bolometric luminosity is $(1.1-1.2)\ 10^{37}$ erg s^{-1}. We can exclude any spectrally hard component with a luminosity of more than $2\ 10^{35}$ erg s^{-1} (for a bremmstrahlung with a temperature of 0.5 keV) at a distance of 60 kpc. The LTE temperature is therefore in the range $5.5 \pm 0.2\ 10^5$ K and the non-LTE temperature in the range $3.25 \pm 0.16\ 10^5$ K.

Assuming the source is on the stability line for atmospheric nuclear burning, we constrain the white dwarf mass from the LTE and the non-LTE fit to $\sim$1.1 M$_\odot$ and $\sim$0.9 M$_\odot$ respectively. However, the temperature and luminosity derived with the non-LTE model for 1E 0035.4-7230 is consistent with a lower mass ($M_{WD} \sim 0.6 - 0.7 M_\odot$) white dwarf as predicted by Sion & Starrfield (1994). At the moment, neither of these two alternatives for the white dwarf mass can be excluded.

Key words: X-rays: stars – accretion – binaries:close – stars: individual (1E 0035.4-7230 (SMC)) – white dwarfs

1. Introduction

The *Einstein* observatory performed a survey of the Small Magellanic Cloud (SMC) in which two sources with unusually soft spectra, 1E 0056.8-7154 and 1E 0035.4-7230, were detected (Seward & Mitchell 1981). 1E 0035.4-7230 has been identified in the optical with a variable blue star with a strong UV excess and a 4.1 hour orbital period (Orio et al. 1994). The supersoft nature of the source was confirmed by subsequent ROSAT observations (Kahabka et al. 1994; Kahabka 1996). Supersoft sources are most probably accreting white dwarfs (WDs) which are burning hydrogen steadily (van den Heuvel et al. 1992). An orbital period of 0.1719 days was found in optical and X-ray data (Crampton et al. 1997; see van Teeseling et al. 1998 for a recent discussion). The optical spectrum shows pronounced emission at HeII λ4686 and near Hα. The Hβ line is seen in absorption (Cowley et al. 1998). The mass function derived from the HeII λ4686 line radial velocities indicates a donor star mass of $\sim$0.4 M$_\odot$ and a WD mass of $\sim 0.5 - 1.4$ M$_\odot$. A scenario to account for the evolutionary state of the source has been proposed by Kahabka & Ergma (1997) in which the system is a cataclysmic variable (CV) with a low-mass WD accreting below the steady-state burning rate. The recurrent flashes in this system are assumed to be mild and leave a fraction of the envelope as a nuclear reservoir. The WD is heated to a high temperature during its evolution (Sion & Starrfield 1994). The Sion & Starrfield models of a 0.6 M$_\odot$ and a 0.7 M$_\odot$ WD predict an asymptotic temperature of $\sim 3.25\ 10^5$ K and a luminosity of $\sim 10^{37}$ erg s^{-1}. X-ray spectroscopy allows the WD mass and temperature to be

Send offprint requests to: ptk@astro.uva.nl

estimated, so allowing the evolutionary status of the system to be probed. If 1E 0035.4-7230 harbors a massive WD ($M_{WD} > 0.7 - 0.8\ M_{\odot}$) then the Sion & Starrfield model may no longer be applicable as the envelope is probably expelled during recurrent nova outbursts. This work is part of a program to systematically observe the brighter supersoft sources with the BeppoSAX satellite (Parmar et al. 1997a, 1998; Hartmann et al. 1999).

2. Observation

The Low-Energy Concentrator Spectrometer (LECS) onboard *BeppoSAX* is an imaging gas scintillation proportional counter sensitive in the energy range 0.1–10.0 keV with a circular field of view of 37′ diameter (Parmar et al. 1997b). Its energy resolution is a factor ∼2 better than that of the ROSAT Position Sensitive Proportional Counter (PSPC). 1E 0035.4-7230 was observed between 1998 January 4 10:27 and January 6 01:21 UTC. Good data were selected from intervals when the minimum elevation angle above the Earth's limb was >5° and when the high voltage levels were nominal using the SAXDAS data analysis package. Since the LECS was only operated during satellite night-time, this gave a total on-source exposure of 37 ks.

Examination of the LECS image shows a source at a position consistent with that of 1E 0035.4-7230. A spectrum was extracted centered on the source centroid using a radius of 8′. This radius was chosen to include 95% of the 0.28 keV photons. The spectrum was rebinned to have >20 counts in each bin to allow the use of the χ^2 statistic. The LECS response matrix from the 1997 September release was used in the spectral analysis. The background spectrum was extracted from the image itself using a semi-annulus centered on 1E 0035.4-7230 with inner and outer radii of 14′ and 19′, respectively. A correction for telescope vignetting was applied (see Parmar et al. 1999). The 1E 0035.4-7230 count rate above background is 0.008 s^{-1}. Examination of the extracted spectrum shows that the source is only detected in a narrow energy range and only the 21 rebinned channels corresponding to energies between 0.13 and 1.7 keV were used for spectral fitting.

3. BeppoSAX spectral fit

Initially only BeppoSAX data was used to constrain the parameters derived from different spectral models. The fits indicate the presence of a C edge at ∼0.5 keV, most likely due to C VI and this provides strong support for a hot and nuclear burning WD atmosphere model.

3.1. Blackbody spectral fits

The BeppoSAX data were first fit with a blackbody spectral model. The fit is acceptable with a χ^2 of 8.5 for 18 degrees of freedom (dof). The blackbody temperature, kT, is (20–52) eV and the column, N_H, $(2.2 - 11)\ 10^{20}$ $H - atoms\ cm^{-2}$. The best-fit luminosity (60 kpc) is 10^{37} erg s^{-1}, but it is not well constrained (cf. Tab.1).

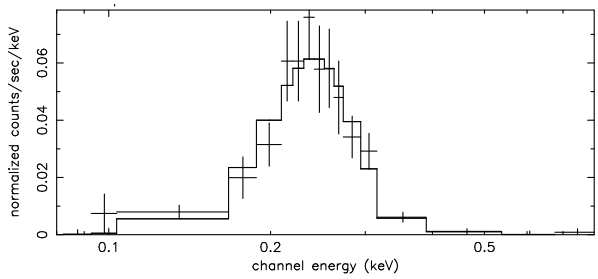

Fig. 1. BeppoSAX count spectrum of the 37 ks observation of 1E 0035.4-7230 together with the best-fit non-LTE spectral fit

Next edges were included in the spectral model.

$$\text{Bbody} \times \text{f(E)} \tag{1}$$

where

$$\text{f(E)} = \begin{cases} 1. & : \quad E < E_{\text{edge}} \\ exp(-\tau \times (\frac{E}{E_{\text{edge}}})^3) & : \quad E \geq E_{\text{edge}} \end{cases} \tag{2}$$

Edges are expected to be present in the atmospheres of hot WDs. Calculations of synthetic spectra have shown that such edges are the dominant spectral features in this energy range. These are likely to be Lyman edges, i.e. ionizations from the ground state of C V and C VI (at energies of 0.391 and 0.487 keV). A single edge with variable energy was first included. As the fit did not allow to constrain the energy of the edge we fixed the edge energy to 0.44 keV, the mean expected energy of the C V and the C VI edge of 0.439 keV. The optical depth, $\tau > 1.8$, at the 68% confidence level. At the 90% confidence level τ cannot be constrained. The χ^2 is 7.1 for 17 dof. The best-fit blackbody kT is 79 eV. The N_H of $(0.8 - 8.8)\ 10^{20}$ $H - atoms\ cm^{-2}$ is in agreement with the foreground column of 3.2 10^{20} $H - atoms\ cm^{-2}$ (derived from the 21-cm map of Stanimirovic et al. 1999). The luminosity is $(0.7 - 8.4)\ 10^{36}$ erg s^{-1}. We applied the F-test statistics and find a probability of ∼70% that a fit including a C-edge is more likely than a fit without an edge (leaving the blackbody temperature in the fit as a free parameter).

Next edges fixed at the energies of the C V and C VI edges were included in the spectral model. The best-fit optical depths are $\tau_{C\ V} \leq 1.8$ and $\tau_{C\ VI} \geq 1.3$ at the 68% confidence level ($\tau_{C\ V} \leq 3.0$ at the 90% confidence level). The best-fit blackbody kT is 63 eV. The N_H is $(2.0 - 6.1)\ 10^{20}$ $H - atoms\ cm^{-2}$, and is in agreement with the galactic foreground column. The luminosity is $(1.0 - 9.6)\ 10^{36}$ erg s^{-1}.

3.2. WD atmosphere spectral fits

A Blackbody spectrum including absorption edges of C V and C VI can only be an approximation to the true spectral distribution. LTE and non-LTE WD atmosphere spectra may be the better approximation (Heise et al. 1994; Hartmann & Heise 1997). We therefore applied LTE and non-LTE WD atmosphere spectra to the BeppoSAX spectrum of 1E 0035.4-7230 assuming reduced abundances for C, N, O and Ne, also in Section 4.2.

The LTE fit is acceptable with a χ^2 of 8.0 for 17 dof. The effective kT is $(4.1-5.9)\ 10^5$ K, the N_H is $(1.6-6.5)\ 10^{20}$ H − atoms cm^{-2} and the best-fit luminosity 3.4 10^{36} erg s^{-1}, the luminosity is not well constrained. The non-LTE fit is also acceptable with a χ^2 of 8.0 for 17 dof. The best-fit effective kT of $(3.3\pm^{0.5}_{0.3})\ 10^5$ K is significantly lower than that derived from the LTE fit. The N_H is $(2.3-6.6)\ 10^{20}$ H − atoms cm^{-2}. The luminosity is in the range $(0.5-3.8)\ 10^{37}$ erg s^{-1}.

4. Combined BeppoSAX and ROSAT PSPC spectral fits

In a second step we used the BeppoSAX spectrum together with a ROSAT spectrum obtained from a 13 ks exposure in 1993 April in a combined (multi-instrument) spectral fit to better constrain the spectral parameters. Fits to the ROSAT data alone are presented in Kahabka et al. (1994). Again the fits indicate the presence of a C edge at ∼0.5 keV, most likely due to C VI and are in strong support for a hot and nuclear burning WD nature of the source.

4.1. Blackbody spectral fits

The data were first fit with a blackbody spectral model. The fit is acceptable with a χ^2 of 40 for 59 dof. The blackbody kT is (39–47) eV, the N_H of $(4.1-6.0)\ 10^{20}$ H − atoms cm^{-2} is greater than the foreground column of 3.2 10^{20} H − atoms cm^{-2}. The bolometric luminosity is $(1-5)\ 10^{37}$ erg s^{-1}. There is no indication of the existence of neutral circumstellar matter (e.g. a nebula) in this system. Any low density matter in the binary system (mass-loss due to winds) found from the modeling of the line profiles of the Balmer lines has been shown to be highly ionized (cf. Asai et al. 1998 for the supersoft source CAL 87 located in the LMC).

Next a single edge with variable energy and depth was included in the spectral model. The fit is acceptable with a χ^2 of 35 for 56 dof. The best-fit indicates an edge energy in the range (0.36–0.47) keV with a best-fit value of 0.44 keV. This value is consistent with the mean expected energy of the C V and the C VI edge (at 0.391 keV and 0.487 keV, respectively) which is 0.439 keV. The derived energy range indicates an ionization state to be somewhere between C V and C VI. The optical depth is $\tau_C > 1.1$ at the 90% confidence level. In this model the blackbody temperature is found to be 48–76 eV. The N_H of $(3.0-5.0)\ 10^{20}$ H − atoms cm^{-2} is in agreement with the foreground column. We applied the F-test statistics and find a probability of ∼70% that a fit including a C-edge is more likely than a fit without an edge (leaving the blackbody temperature in the fit as a free parameter). As before, the edge energies were next fixed at the values appropriate to C V and C VI edges in the spectral fit. The fit is acceptable with a χ^2 of 35 for 56 dof. The best-fit optical depths are $\tau_{C\ V}$= 0.9–2.6 and $\tau_{C\ VI}$=1.1–7.5 at 68% confidence, $\tau_{C\ V} < 2.9$ at 90% confidence. The blackbody kT is in the range 50–81 eV. Using the Saha equation we may constrain the electron density (cf. Sect. 5.1). The N_H of $(3.1-5.1)\ 10^{20}$ H − atoms cm^{-2} is in agreement with the galactic foreground column.

4.2. WD atmosphere spectral fits

The LTE fit assuming reduced abundances is acceptable with a χ^2 of 47 for 59 dof. The effective kT is $(5.5\pm 0.2)\ 10^5$ K, the N_H is $(3.6\pm0.8)10^{20}$ H − atoms cm^{-2}, the bolometric luminosity is $(3-7)\ 10^{36}$ erg s^{-1}. With non-LTE WD atmosphere spectrum and assuming reduced abundances (cf. section 3.2) significantly lower kT of $(3.25\pm 0.16)\ 10^5$ K is found. The derived N_H is $(4.1\pm0.8)\ 10^{20}$ H − atoms cm^{-2}. The fit is acceptable with a χ^2 of 46 for 58 dof. The bolometric luminosity is $(1.0-1.2)\ 10^{37}$ erg s^{-1}.

5. Discussion

We find strong evidence in the BeppoSAX and ROSAT spectra for the presence of an edge at ∼0.44 keV in the spectrum of 1E 0035.4-7230. This edge originates from a combination of C V and C VI with a large optical depth $\tau > 1.1$ (90% confidence).

The temperatures and absorbing columns derived from the blackbody fits should be treated with caution and more reliable estimates are probably obtained with the LTE or non-LTE WD atmosphere model fits. The resulting chi-squared values do not allow to decide between both models. Therefore, the temperature is constrained to the range $(3-6)\ 10^5$ K and the ionization state of C is likely between C V and C VI. The discovery of deep C edges in the spectrum of 1E 0035.4-7230 has implications as it is assumed that the metallicity of the SMC material is heavily reduced (by a factor 3–20, Pagel 1993). Reduced CNO abundances result in less violent outbursts. This can sustain nuclear burning for long periods of time without the requirement of additional supply due to accretion e.g. by X-ray induced heating of the donor star (van Teeseling & King 1998; King & van Teeseling 1998). It is unclear what enhances the C abundance in the envelope of the WD. If the WD goes through recurrent weak outbursts then the CO core may be affected (i.e. eroded) during the out-

Table 1. Results of spectral fitting of the BeppoSAX LECS spectrum (0.1–1.7 keV) and combined BeppoSAX LECS and ROSAT PSPC spectrum of 1E 0035.4-7230. The (0.1–2.4) keV luminosity L_{36} (10^{36} erg s^{-1}) and for the combined ROSAT PSPC and BeppoSAX LECS spectral fit also the bolometric luminosity L_{36} (10^{36} erg s^{-1}) is given. 90% confidence parameter ranges are given ([a] 68% confidence parameter range is given).

BeppoSAX LECS								
Model	N_H (10^{20} cm^{-2})	kT (eV; 10^5 K)	$E_{C\ V}$ (keV)	$E_{C\ VI}$ (keV)	$\tau_{C\ V}$ Edge	$\tau_{C\ VI}$ Edge	L_{36} (0.1-2.4 keV)	χ/dof
bbody	$4.7\pm^{6.8}_{2.5}$	$39\pm^{13}_{19}$ $4.5\pm^{1.5}_{2.2}$					$10\pm^{>10}_{9.3}$	0.47
bbody+edge	$2.2\pm^{6.6}_{1.4}$	$79\pm^{19}_{55}$ $9.2\pm^{2.2}_{6.3}$	0.44		$> 1.8^a$		$2.2\pm^{6.2}_{1.5}$	0.42
bbody+CV+CVI edge	$3.1\pm^{3.0}_{2.1}$	$63\pm^{33}_{23}$ $7.3\pm^{2.9}_{2.2}$	0.391	0.487	$0.4\pm^{2.6}_{0.4}$	$> 1.3^a$	$2.8\pm^{6.8}_{1.8}$	0.57
LTE WD atm.	$3.3\pm^{3.2}_{1.7}$	$47\pm^{3}_{12}$ $5.5\pm^{0.4}_{1.4}$					$3.4\pm^{82}_{3.1}$	0.47
Non-LTE WD atm.	$4.0\pm^{2.6}_{1.7}$	$28\pm^{4}_{3}$ $3.3\pm^{0.5}_{0.3}$					$8.6\pm^{29}_{3}$	0.47

BeppoSAX LECS + ROSAT PSPC									
Model	N_H (10^{20} cm^{-2})	kT (eV; 10^5 K)	$E_{C\ V}$ (keV)	$E_{C\ VI}$ (keV)	$\tau_{C\ V}$ Edge	$\tau_{C\ VI}$ Edge	L^c_{36} (0.1-2.4 keV) (bolometric)	scaling factor[b]	χ/dof
bbody	$4.8\pm^{1.1}_{0.8}$	$43\pm^{4}_{4}$ $5.0\pm^{0.5}_{0.5}$					$9.3\pm^{11}_{4.2}$ $12\pm^{42}_{9}$	$1.68\pm^{0.23}_{0.19}$	0.68
bbody+edge	$3.8\pm^{1.1}_{0.8}$	$63\pm^{13}_{15}$ $7.3\pm^{1.5}_{1.7}$	$0.44\pm^{0.03}_{0.08}$		$5.4\pm^{3.6}_{2.7}{}^a$		$4.2\pm^{3.8}_{1.5}$ $5.2\pm^{0.9}_{2.0}$	$1.67\pm^{0.23}_{0.17}$	0.62
bbody+CV+CVI edge	$3.9\pm^{1.2}_{0.8}$	$65\pm^{16}_{15}$ $7.5\pm^{1.5}_{1.7}$	0.391	0.487	$1.6\pm^{1.0}_{0.7}{}^a$	$3.9\pm^{3.6}_{2.8}{}^a$	$4.2\pm^{3.3}_{1.4}$ $5.4\pm^{3.6}_{3.5}$	$1.68\pm^{0.14}_{0.12}$	0.63
LTE WD atm.[d]	$3.6\pm^{0.4}_{0.4}$	$47\pm^{1}_{1}$ $5.5\pm^{0.1}_{0.1}$					$2.0\pm^{1.4}_{0.8}$ $4.8\pm^{1.1}_{0.8}$	$1.68\pm^{0.2}_{0.1}$	0.80
Non-LTE WD atm.[d]	$4.1\pm^{0.4}_{0.3}$	$28\pm^{0.6}_{0.8}$ $3.25\pm^{0.07}_{0.09}$					$9.8\pm^{4.0}_{1.4}$ $10.9\pm^{0.3}_{0.3}$	$1.30\pm^{0.15}_{0.14}$	0.77

[b] the flux scaling factor is ($flux_{ROSATPSPC}$ / ($flux_{BeppoSAX}$), [c] the luminosity is given for the BeppoSAX spectrum. [d] 68% confidence errors are given. In the text estimates for the 90% errors are given as twice the 68% errors.

burst. Eroded core material (i.e. C and O) may be mixed into the envelope. But as no N is supplied, it cannot affect the CNO cycle, i.e. it will not enhance the strength of the outburst. The soft X-ray spectrum of 1E 0035.4-7230 ressembles that of the symbiotic nova RX J0048.4-7332 in the SMC (Jordan et al. 1996). For this source a strong C V edge is also required in the spectral modelling. We applied to the *ROSAT PSPC* spectrum of this source a blackbody spectrum including a C V and a C VI edge and find $\tau_{C\ V} \geq 5.8$ and $\tau_{C\ VI} \geq 0.57$ (68% confidence). The best-fit blackbody temperature is $\sim$4 10^5 K, somewhat above the temperature derived from the non-LTE fit by Jordan et al. (1996). These authors find a strong stellar wind with a mass-loss rate of $\sim 10^{-6}$ $M_\odot$ yr^{-1} for the symbiotic nova.

5.1. Constraints inferred from the Saha equation

Using the Saha equation we can predict the ratio of the depth in the C V and C VI edges assuming realistic values for the electron density in hot atmospheres of WDs and compare this ratio with that derived from observation. Considering only the ground state of ions, the Saha equation is

$$\frac{N^+}{N} N_e = \left(\frac{2\pi m_e kT}{h^2}\right)^{3/2} \frac{2g^+}{g}\ e^{-\chi_i/kT}. \quad (3)$$

Here N is the particle density and + designates the ionized state, N_e is the electron density, g and g^+ are the statistical weights of the ions, and χ_i is the ionization energy. For C V and C VI these weights are $g_{C\ V} = 1$ and $g_{C\ VI} = 2$ with $\chi_{C\ V-C\ VI} = 6.3\ 10^{-17}$ J = 392 eV. We assume for the optical depth $d\tau = N\sigma ds$ and $d\tau^+ = N^+\sigma^+ ds^+$. σ is the threshold photoionization cross-section and ds is the radial distance travelled by a photon. The definition of an absorption edge in Section 3.1 allows us to put $ds = ds^+$ since all blackbody radiation passes through the same absorbing slab of material. Then we get

$d\tau = N\sigma ds$ and $d\tau^+ = N^+\sigma^+ ds$ gives

$$\frac{N^+}{N} \approx \frac{\tau^+\sigma}{\tau\sigma^+} \tag{4}$$

and

$$N_e = \frac{\tau\sigma^+}{\tau^+\sigma}\left(\frac{2\pi m_e kT}{h^2}\right)^{3/2}\frac{2g^+}{g}e^{-\chi_i/kT} \tag{5}$$

with $\sigma = 4.7\ 10^{-19}$ cm^{-2} and $\sigma^+ = 1.810^{-19}$ cm^{-2} (Verner et al. 1996).

For C V and C VI the electron density can be written as

$$N_e = 1.1710^{23}\ T_5^{3/2}\frac{\tau}{\tau^+}e^{-\chi_i/kT}\ \mathrm{cm}^{-3} \tag{6}$$

with the temperature T_5 in units of 10^5 K. Constraining the temperature to be in the range $(4-6)\,10^5$ K gives

$$N_e = (0.11-8.8)\,10^{20}\ \frac{\tau}{\tau^+}\ \mathrm{cm}^{-3}. \tag{7}$$

For high gravity (log g=9.0) WD atmospheres electron densities in the range ($10^{19} - 10^{20}$ cm^{-3}) are expected. Such densities are achieved for ratios in the range $\frac{\tau}{\tau^+} \sim 0.1 - 1$. The range derived from the blackbody and edge fit $\frac{\tau}{\tau^+} \sim 0.1 - 2$ is therefore consistent with that predicted.

5.2. The evolutionary state of 1E 0035.4-7230

The temperature and luminosity derived from the different spectral models can be compared with the asymptotic temperature of 3.25 10^5 K and the bolometric luminosity of $\gtrsim 10^{37}$ erg s^{-1} predicted by Sion & Starrfield (1994) for a low-mass ($M_{WD} \sim 0.6 - 0.7\ M_\odot$) WD accreting at a rate of $\sim 10^{-8}$ $M_\odot$ yr^{-1} and burning hydrogen steadily for thousands of years. With the non-LTE model a kT of (3.25 ± 0.16) 10^5 K and a bolometric luminosity of $(1.0 - 1.2)$ 10^{37} erg s^{-1} are derived, in agreement with the predictions from the Sion & Starrfield model. The LTE model gives a higher effective kT of 5.5 ± 0.2 10^5 K and a somewhat lower bolometric luminosity of $(3 - 7)$ 10^{36} erg s^{-1}. Such a temperature is consistent with a more massive WD $M_{WD} \sim 1.1\ M_\odot$, assuming the stability relation in Iben (1982) (see Kahabka 1998). However the predicted luminosity is at least a factor of 10 too low in order to be explained by steady nuclear burning. This could be either due to obscuration of the source which is seen at a large inclination of $\sim 40°$ (cf. van Teeseling et al. 1998), or due to reduced nuclear burning. The X-ray luminosity of the source appeared not to have varied by more than $\sim 1.30 \pm 0.3$ between the ROSAT and BeppoSAX observations. We cannot exclude that this change in luminosity could be of instrumental nature due to the uncertain cross-calibration of the BeppoSAX LECS and the ROSAT PSPC instruments. It also may be due to changing X-ray scattering in the binary system. If it is due to a long-term change in the luminosity caused by a cooling of the WD envelope then a temperature change by a factor of 1.07 ± 0.05 would be required to account for the derived change in luminosity.

The extreme softness of the spectrum of 1E 0035.4-7230 allows constraints to be set on the existence of a spectrally hard component in this system. Such a component may be expected if there is a strong colliding wind present. A wind with a mass-loss rate of $\sim 10^{-6}$ $M_\odot$ yr^{-1} with a terminal velocity of $\sim$500 km s^{-1} from a low-mass WD and a mass-loss rate of $\sim 10^{-7}$ $M_\odot$ yr^{-1} with a lower terminal velocity from the donor star (as e.g. proposed by van Teeseling & King 1998) should give rise to a colliding wind. We do not detect such a component from the BeppoSAX observation. We derive a 90% confidence upper limit luminosity for a bremsstrahlung component with a temperature of 0.5 keV (assuming a distance of 60 kpc) of 2 10^{35} erg s^{-1}. This upper limit is too large to compare with the luminosity of colliding winds observed e.g. by Jordan et al. (1994) in the galactic symbiotic nova RR Tel of $\sim$2 10^{32} erg s^{-1}.

Acknowledgements. This research was supported in part by the Netherlands Organization for Scientific Research (NWO) through Spinoza Grant 08-0 to E.P.J. van den Heuvel. The *BeppoSAX* satellite is a joint Italian–Dutch programme. We thank the staff of the *BeppoSAX* Science Data Center for their support.

References

Asai K., Dotani T., Nagase F., et al., 1998, ApJ 503, L143
Cowley A.P., Schmidtke P.C., Crampton D., Hutchings J.B., 1998, ApJ 504, 854
Crampton D., Hutchings J.B., Cowley A.P., et al., 1997, ApJ 489, 903
Hartmann H.W., Heise J., 1997, A&A 322, 591
Hartmann H.W., Heise J., Kahabka P., Motch C., Parmar A.N., 1999, A&A (in press)
Heise J., van Teeseling A., Kahabka P., 1994, A&A 288, L45
Iben I.Jr., 1982, ApJ 259, 244
Jordan S., Mïset U., Werner K., 1994, A&A 283, 475
Jordan S., Schmutz W., Wolff B., et al., 1996, A&A 312, 897
Kahabka P., Pietsch W., Hasinger G., 1994, A&A 288, 538
Kahabka P., 1996, A&A 306, 795
Kahabka P., Ergma E., 1997, A&A 318, 108
Kahabka P., 1998, A&A 332, 189

King A.R., van Teeseling A., 1998, A&A 338, 965
Orio M., Della Valle M., Massone G., 1994, A&A 289, L11
Pagel B.E.J., 1993, Stellar vs. Interstellar Abundances in the Magellanic Clouds, in: Lecture Notes in Physics 416, New Aspects of Magellanic Cloud Research, eds. Baschek B., Klare G., Lequeux J., 330
Parmar A.N., Martin D.D.E., Bavdaz M., et al., 1997a, A&AS 122, 309
Parmar A.N., Kahabka P., Hartmann H.W., et al., 1997b, A&A 323, L33
Parmar A.N., Kahabka P., Hartmann H.W., et al., 1998, A&A 332, 199
Parmar A.N., Oosterbroek T., Orr A., et al., 1999, A&AS (submitted)
Seward F.D., Mitchell M., 1981, ApJ 243, 736
Sion E.M., Starrfield S.G., 1994, ApJ 421, 261
Stanimirovic S., Staveley-Smith L., Dickey J.M., et al., 1999, MNRAS 302, 417
Van den Heuvel E.P.J., Bhattacharya D., Nomoto K., Rappaport S.A., 1992, A&A 262, 97
Van Teeseling A., Reinsch K., Pakull M.W., et al., 1998, A&A 338, 947
Van Teeseling A., King A.R., 1998, A&A 338, 957
Verner, D.A., Ferland, G.J., Korista, K.T. & Yakovlev, D.G. 1996, ApJ 465, 487

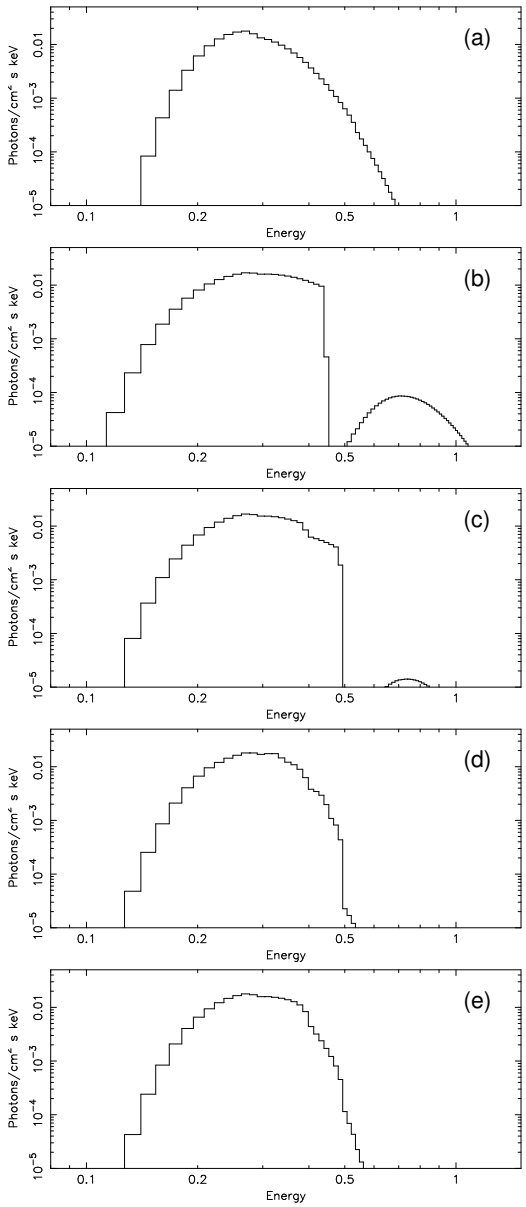

Fig. 2. (a) Best-fit blackbody model. The blackbody kT is 39 eV and the column 4.7 10^{20} H − atoms cm^{-2}.(b) Best-fit blackbody model with an edge at 0.44 keV. The optical depth is larger than 1.8 (68% confidence). The blackbody kT is 79 eV and the column 2.2 10^{20} H − atoms cm^{-2}. (c) Best-fit blackbody model with a C V edge at 0.391 keV and a C VI edge at 0.487 keV. The optical depths are 0.4 and >1.3, respectively. The blackbody kT is 63 eV and N_H 3.1 10^{20} H − atoms cm^{-2}. (d) Best-fit LTE WD atmosphere model. The kT is 5.5 10^5 K and N_H 3.3 10^{20} H − atoms cm^{-2}. (e) Best-fit non-LTE WD atmosphere model. The kT is 3.9 10^5 K and N_H 3.5 10^{20} H − atoms cm^{-2}

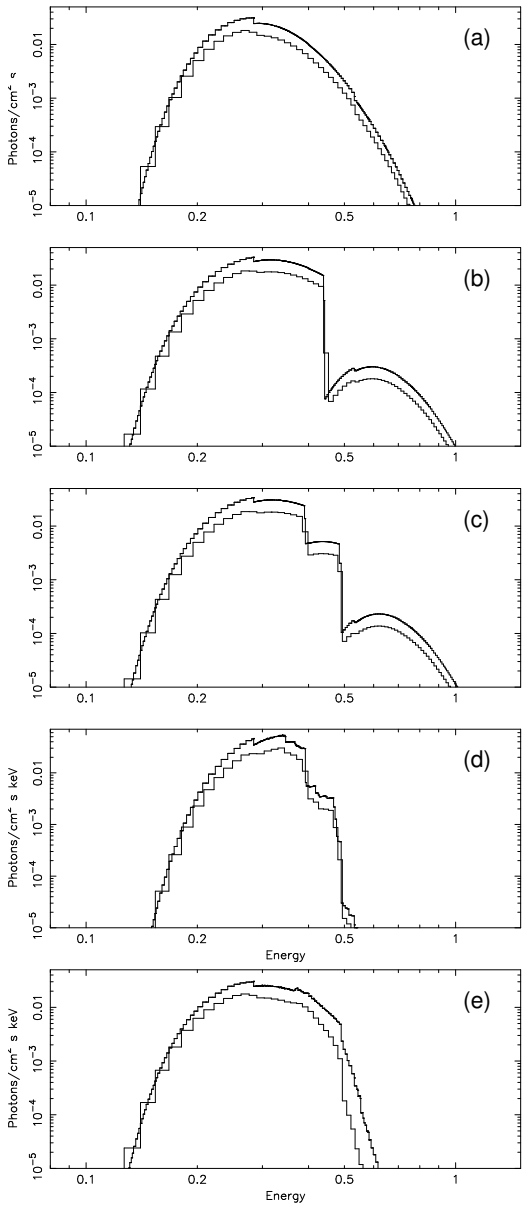

Fig. 3. (a) Best-fit blackbody model. The blackbody kT is 43 eV and N_H is 4.9 10^{20} H − atoms cm^{-2}. (b) Best-fit blackbody model with an edge at 0.44 keV. The optical depth is 5.4. The blackbody kT is 63 eV and N_H is 3.8 10^{20} H − atoms cm^{-2}. (c) Best-fit blackbody model with a C V edge at 0.391 keV and a C VI edge at 0.487 keV. The optical depths are 1.6 and 3.9, respectively. The blackbody kT is 65 eV and N_H is 3.9 10^{20} H − atoms cm^{-2}. (d) Best-fit LTE WD atmosphere model. The kT is 5.5 10^5 K, and the N_H 3.6 10^{20} H − atoms cm^{-2}. (e) Best-fit non-LTE WD atmosphere model. The kT is 3.25 10^5 K, and the N_H 4.1 10^{20} H − atoms cm^{-2}.