The active binary star II Pegasi with *Beppo*SAX

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Abstract. II Peg is an ideal target to study stellar activity and flares, since intense and long lasting flares have been frequently detected from this system at all wavelengths. We report here about a *Beppo*SAX observation of II Peg. We followed the system for ~ 19 hours on December 5 and 6 1997 with *Beppo*SAX and the X-ray light curve resembles the typical behavior of a decay phase of a long-lasting flare. The spectral analysis shows that the II Peg X-ray spectrum is described by a two–temperature components, with the two dominant temperatures centered in the range of 9–11 and 24–26 MK. The derived coronal metal abundance is low ($Z \sim 0.2 Z_\odot$) compared to recent determinations of the photospheric abundance ($Z \sim 0.6 Z_\odot$). Some possible explanations for this phenomenology are reviewed. As for most other stellar coronal sources observed with *Beppo*SAX, we find that in order to fit the *Beppo*SAX spectra an interstellar column density about a factor ten higher than previously determined is required.

Key words: stars: activity – stars: coronae – stars: flare – stars: individual: II Peg – X-rays: stars

1. Introduction

The Italian-Dutch satellite *Beppo*SAX, thanks to the wide energy range covered by its detectors, has led to important contributions in the field of stellar corona phenomenologies. Indeed, hard X-ray emission above 10 keV has been, for the first time, detected during strong flares from UX Ari (Pallavicini & Tagliaferri 1998), Algol (Favata 1998) and AB Dor (Pallavicini et al. 1999). These observations have also allowed time-resolved spectroscopy of flares and the determination of coronal metallicities on a wide energy band (from 0.1 to more than 10 keV, see, e.g. Favata 1998 and Pallavicini et al. 1999 for reviews of early *Beppo*SAX results).

With this aims in mind, we have observed with *Beppo*SAX the active RS CVn star II Peg (HD 224085; BD +27 4642), a single–line spectroscopic binary with a period of 6.7 days composed of a primary of K2 IV-V spectral type and an unobserved companion (Vogt 1981). The distance has normally been as-

sumed to be ~ 30 pc, as derived by the parallax of 0.034" (Jenkins 1963, Vogt 1981), however the new *Hipparcos* satellite measurements give a value of $d = 42 \pm 1.6$ pc (23.62 ± 0.89 mas). This system (global $V \sim 7.62$; $B-V \sim 1.01$) shows luminosity variations up to 0.5 mag presumably due to rotational modulation (see, for instance, Berdyugina et al. 1998b and O'Neal et al. 1998). A detailed study of the stellar and orbital features of this system has been recently reported by Berdyugina et al. (1998a).

Intense flares have been observed on II Peg from the the radio to the optical, UV and X-ray bands. This flaring activity is particularly pronounced at higher frequencies; flares have been observed by *Ariel V* (Schwartz 1981), in all IUE runs in 1981, 1983, 1985 and 1986 (Doyle et al. 1989) and also in the EUV band with the EUVE satellite (Mewe et al. 1997). In the X-rays, three strong flares have been observed with EXOSAT, GINGA and ASCA, with an energy release of $> 2 \times 10^{35}$ erg in the first two cases. The flare seen by EXOSAT in the 0.05–7 keV energy band lasted longer than a day, with a rise time of ~ 3 hours, a peak phase of at least 2 hours and a long decay unfortunately not continuously observed by EXOSAT because of perigee passages. The quiescent value was reached again only two days after the occurrence of the peak of the flare (Tagliaferri et al. 1991). The intense GINGA flare has been only partially observed during the decay phase, however it was still so intense to be detected up to 18 keV, with a power-law tail at energies greater than 10 keV (Doyle et al. 1992). Finally, the ASCA flare lasted for about 18 hours, with an enhancement of a factor of ~ 4 in the iron abundance during the rise phase of the flare (Mewe et al. 1997) and a total energy of 2.7×10^{34} erg.

Quiescent X-ray emission from II Peg has also been observed by the ROSAT PSPC during the ROSAT All-Sky Survey (RASS, Dempsey et al. 1993a and 1993b) and as a pointed target (Huenemoerder & Baluta 1998). The RASS observation showed a luminosity of $\sim 6 \times 10^{30}$ erg s^{-1} with a bimodal temperature distribution with a high and a low temperature component of $2(\pm 0.5)$ and $21(\pm 5)$ MK, respectively. The emission measure ratio, $EM_{\text{low}}/EM_{\text{high}}$ was ~ 0.06 and no interstellar absorption was constrained by the data (Dempsey et al. 1993b). The pointed observation lasted 60 Ksec for an eventual 18 Ksec effective observing time. The best-fit bimodal temperature distribution gave a luminosity of $\sim 7 \times 10^{30}$ erg s^{-1}, high and low temperature components of $13(\pm 1)$ and $\sim 3(\pm 0.2)$ MK

with $EM_{low}/EM_{high} \sim 0.33$ and interstellar absorption of $N_H = 7(\pm 5) \times 10^{18}\,cm^{-2}$. Eventually, the best–fit coronal metal abundance turned out to be 0.3–0.4 (± 0.1) Solar.

Since both the EXOSAT and GINGA flares were observed during the minima of the photometric wave, and a large number of UV and optical flares have been observed at the same phase, we have followed II Peg for ~ 19 hours close to the minimum phase, on 1997, December 5 and 6, with the purpose of detecting an intense flare as those observed by EXOSAT, GINGA and ASCA. Moreover, since simultaneous multi-wavelength observations of stellar flares are extremely important to study the physical processes that drive thermal and non-thermal coronal plasmas (e.g. Haisch & Rodonò 1989 and references therein), we arranged for simultaneous optical observations in the standard B and V filters.

This paper is organized as follows. In Sect. 2 we describe the data sample and the analysis technique applied. In Sect. 3 the results are presented, and they are finally discussed in Sect. 4.

2. The data

The *Beppo*SAX satellite carries aboard a number of X-ray detectors able to cover a wide energy range, from 0.1 to 300 keV (Boella et al. 1997a). Actually, apart from some very intense X-ray flares, the study of coronal sources can only be performed with the Low Energy Concentrator Spectrometer (LECS, Parmar et al. 1997) and the two Medium Energy Concentrator Spectrometers (MECS, Boella et al. 1997b). Still these instruments are sensitive to a large energy range. In particular the LECS covers the range from 0.1 to 10 keV, with a spectral resolution comparable at the lowest energies to that of CCD detectors (such as those used on ASCA). Favata et al. (1997c) have argued on the basis of spectral simulations of ASCA and *Beppo*SAX LECS spectra that the broader spectral band of the latter instrument should allow a better determination of the overall coronal metallicity, even if the lower resolution at higher energies makes it difficult to determine the individual metal abundances. The MECS detectors cover only the 1.7–10 keV energy range but they have an effective area about two times larger than that of the LECS, allowing the study of the Fe K complex at ~ 6.7 keV more effectively.

*Beppo*SAX observed II Peg from December 5 to 6 1997 for about 19 hours (observation sequential number 10161001), yielding ~ 15 ks and ~ 35 ks of effective observing time in the LECS and MECS detectors, respectively. The difference in exposure time is due to the fact that the LECS can only operate when in the Earth shadow. The data analysis has been based on the linearized, cleaned, event files, obtained by the *Beppo*SAX Science Data Center (SDC; Giommi & Fiore 1997) on-line archive.

The light curves and spectra were extracted using the FTOOLS (v. 4.0) package, with an extraction region of 8'.5 and 4' radius for the LECS and the MECS, respectively. The different regions are due to a broader Point Spread Function (PSF) for the LECS at low energies, while above 2 keV the LECS and MECS PSFs are essentially comparable. The considered

extraction regions contain more than 90% of the counts for all energies. The light curve analysis has been performed with the XRONOS (v. 4.02) package, while for the spectral analysis we used the XSPEC (v. 10.0) package, with the response matrices released by the SDC in September 1997. The spectra were rebinned following the recipe provided by the SDC. The rebinning samples the instrumental resolution with the same number of channels, three in our case, at all energies. LECS and MECS background spectra were accumulated from blank fields available at the public SDC ftp site (see Fiore et al. 1999; Parmar et al. 1999). LECS data have been analyzed only in the 0.1–4 keV range due to still unsolved calibration problems at higher energies (Fiore et al. 1999). The LECS and MECS spectra were always conjunctly fit after having allowed a rescaling factor for LECS data in order to take into account the uncertainties in the inter-calibration of the detectors. The rescaling factor turned out to be ~ 0.75, which is within the acceptable range of $0.7 \div 1$ (Fiore et al. 1999). Therefore, we kept this constant value fixed to 0.75 in all our spectral analyses. For a full description of the analysis techniques of *Beppo*SAX data see Fiore et al. (1999).

As mentioned above, interesting spectral information could also be obtained in some cases from the Phoswich Detector System (Frontera et al. 1997) aboard *Beppo*SAX, even if this detector had been designed to provide the best sensitivity at energies relatively higher than those typical for a stellar corona. The energy range covered by the PDS is from 15 to 300 keV. Hard X-ray emissions (> 20 keV) have been detected during strong flares from active stars (Pallavicini et al. 1999). During the present II Peg observation, however, no convincing evidence of a PDS detection has been found. This is not surprising since coronal sources have been detected with the PDS only during the rise and the peak phase of strong X-ray flares, and not during the decay phase (which was the only one observed for II Peg).

The optical observations were performed in the standard BV filters, using the Marcon 50-cm telescope of the Brera Astronomical Observatory at Merate (Italy), equipped with a photon-counting photometer (EMI 9789QA). HR 9088 (85 Peg) and HR 8997 (78 Peg) were used as comparison stars.

3. Results

In Fig. 1 we show the total II Peg MECS light curve and the 2.0–10.0 keV / 0.1–1.5 keV (MECS/LECS) hardness ratio. The best fit exponential plus constant fit of the MECS light curve is also shown. The quiescent value determined at the end of the observation turns out to be ~ 0.27 Cts s^{-1} while the flare decay time is ~ 5.3 hours. The background amounts only to roughly one hundredth of the source flux and has been stable for the whole observation. Variability is clearly present, the flux in the $2 \div 10$ keV band decreases by a factor ~ 2 in about 10 hours. This behavior would suggest that we are observing the tail of a long-lasting flare. Unfortunately, the optical observations do not help in this respect since during the *Beppo*SAX observation bad weather at Merate prevented us to perform any II Peg photometry. Observations could only be performed on the next night (December 6–7) when the source did not show any sign
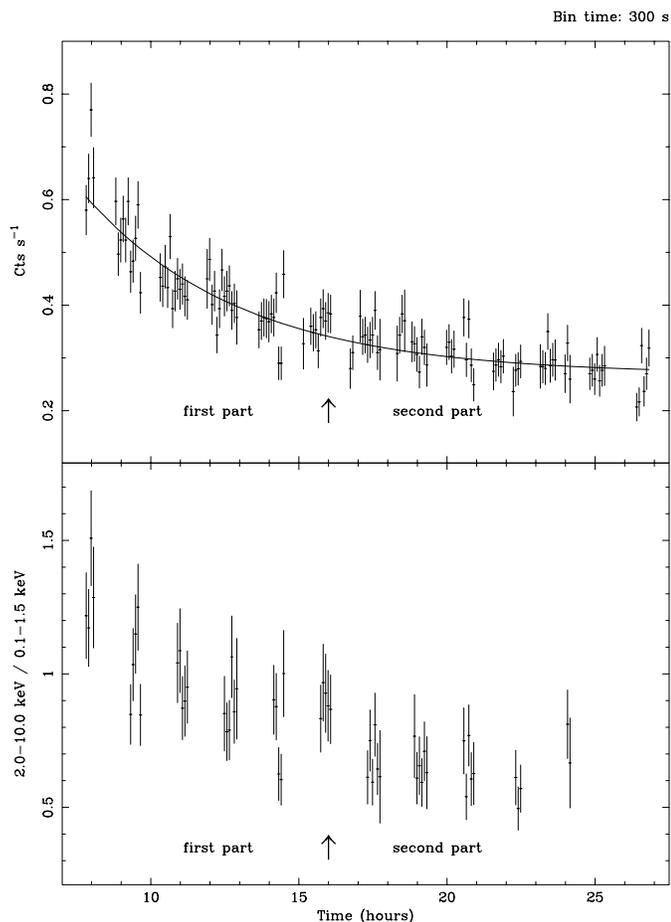
Fig. 1. *Top panel:* II Peg MECS light curve in the energy range from 2 to 10 keV. The solid line shows the best fit exponential plus constant curve. The quiescent flux at the end of the observation turns out to be $\sim$ 0.27 Cts s^{-1} and the decay time $\sim$ 5.3 hours. The background has been stable during the observation and amounts to roughly one hundredth of the source flux in the MECS cameras. *Bottom panel:* Hardness ratio between 2.0–10.0 keV (MECS) data and 0.1–1.5 keV (LECS) data. The binning time is 300 s. The observation started on December 5 1997 and the arrow signs the separation between the first and the second part of the observation considered in the spectral analysis.

of activity. No variability larger than the observational uncertainties was detected; the standard deviations of the differential measurements HD 224016-II Peg (± 0.01 mag in both colors) are similar to those measured between the comparison stars.

For the spectral analysis, we have applied the thin plasma models by Raymond & Smith (1977; RS) and Mewe et al. (1996a; MEKAL) as implemented in XSPEC. No significant differences have been found in the results obtained with the two models and therefore we report here only the MEKAL results. The errors on the counts have been taken into account by the Gehrels (1986) approximation for data following the Poissonian statistics, rather than the less adequate Gaussian statistics. Our data are always in the Gaussian regime but for energies above $\sim$ 6 keV for the MECS cameras, below $\sim$ 0.2 keV and around $\sim$ 0.4 keV for the LECS camera. The χ^2 minimization statistics was applied throughout the paper.

Abundance variations in the source spectrum have been modeled through the use of a single parameter, the global "metallicity" Z, by assuming a fixed ratio between individual elemental abundances and the corresponding solar photospheric values as given by Anders & Grevesse (1989).

The interstellar absorption N_H has been included in the fit. At first, we have allowed N_H to vary freely in the fit procedure and the best–fit value was $\sim 8 \times 10^{19}$ cm^{-2} (see Table 1). This value is more than a factor of ten higher then the one obtained by the analysis of ROSAT (Huenemoerder & Baluta 1998), EXOSAT and EUVE data (Tagliaferri et al. 1991; Mewe et al. 1997) where the derived interstellar reddening amounted to 5–8$\times 10^{18}$ cm^{-2}. Indeed, applying the relation $H \sim 0.07$ cm^{-3} (Paresce 1984) a value of $N_H \sim 9 \times 10^{18}$ cm^{-2} is obtained, rather close to the value obtained by the analyses of ROSAT, EXOSAT and EUVE data and still an order of magnitude lower than the result obtained by the fit of *Beppo*SAX data.

In order to minimize the number of free parameters and also the effect that N_H could have on the derived metallicity (a higher N_H could be compensated by a low metal abundance in the fit procedure), we have also fitted our data freezing N_H to 5×10^{18} cm^{-2}. The results are reported in Table 2.

Satisfactory fits to the data were not possible with single–temperature models. Two–temperature models with N_H fixed to 5×10^{18} cm^{-2} were also not able to provide satisfactory fits to the data and strong residuals are clearly visible below 0.4 keV (Fig. 2). To check if this result could be related to the source variability the observation was subdivided in two distinct parts (Fig. 1), and LECS and MECS spectra were accumulated for the first and second part separately. However, even in these two cases we did not obtain any satisfactory fits with this N_H value (Table 2) and the results for the two time intervals were essentially indistinguishable.

In all three cases significant improvement to the fits are obtained by two–temperature models with N_H and the metal abundance free to vary. In these cases the metal abundance value is lower and more similar to the value found from the ROSAT (Huenemoerder & Baluta 1998), ASCA and EUVE data (Mewe et al. 1997). The best–fit models are shown in Figs. 2 and 3 and refer to two–temperature MEKAL models for the whole data set with N_H either frozen to $N_H = 5 \times 10^{18}$ cm^{-2} or free to vary. Consequently, our *Beppo*SAX data can be only fitted assuming a large N_H. A similar result was obtained for *Beppo*SAX observations of the coronal sources VY Ari, HD 9770, UX Ari, AB Dor and AR Lac (Favata et al. 1997b, Tagliaferri et al. 1999, Pallavicini & Tagliaferri 1998; Pallavicini et al. 1999, Rodonò et al. 1999). This anomaly may be due either to a problem in the calibration of the LECS detector below 0.5 keV (i.e. where N_H is estimated in case of values lower than $\sim \times 10^{20}$ cm^{-2}) or to an incorrect source modeling evidenced by the wide *Beppo*SAX energy range.

Two-temperature fits performed removing the energy channels below 0.4 keV show that any interstellar absorption (up to few $\times 10^{20}$ cm^{-2}) is adequate to fit the data (i.e. N_H is no more constrained). The fits are always statistically acceptable ($\chi^2 \sim 1.1 \div 1.2$) and the metal abundance remains unchanged

Table 1. Best fit parameters with two–temperature MEKAL models. Spectra have been analyzed considering both the whole data set and the first and second part of the observation alone (see also Fig. 1). The interstellar reddening N_H was free to vary during the fits, the fluxes are corrected for the absorption. Assuming a 42 pc distance, the luminosity turns out to be $\sim 10^{31}\,\mathrm{erg\,s^{-1}}$. The errors on the parameters are at 90% for four parameters of interest. The fits are satisfactory but N_H is an order of magnitude larger than expected.

	N_H $10^{19}\,\mathrm{cm^{-2}}$	KT_1 (keV)	KT_2 (keV)	$Z/Z_\odot$	$\frac{EM_1}{EM_2}$	flux$_{0.1\text{-}2.4\,\mathrm{KeV}}$ $\frac{\mathrm{erg}}{\mathrm{s\,cm^2}}\times 10^{-11}$	d.o.f.	χ^2
Tot. Sample	$7.8\pm^{2.2}_{2.8}$	$1.04\pm^{0.09}_{0.09}$	$2.55\pm^{0.11}_{0.11}$	$0.16\pm^{0.04}_{0.04}$	0.60	5.1	86	1.0
1st Part	$8.3\pm^{4.2}_{3.3}$	$1.05\pm^{0.16}_{0.14}$	$2.68\pm^{0.38}_{0.15}$	$0.17\pm^{0.06}_{0.06}$	0.44	5.3	86	0.8
2nd Part	$7.8\pm^{5.4}_{5.7}$	$1.03\pm^{0.12}_{0.48}$	$2.45\pm^{1.06}_{0.59}$	$0.14\pm^{0.14}_{0.05}$	1.02	4.9	86	1.1

Table 2. Best fit parameters with two–temperature MEKAL models. Spectra have been analyzed considering both the whole data set and the first and second part of the observation alone (see also Fig. 1). The N_H value has been frozen to $5\times 10^{18}\,\mathrm{cm^{-2}}$, the fluxes are corrected for the absorption. Assuming a 42 pc distance, the luminosity turns out to be $\sim 9\times 10^{30}\,\mathrm{erg\,s^{-1}}$. The errors on the parameters are at 90% for three parameters of interest. The fits are worse than those in Table 1 and formally unacceptable.

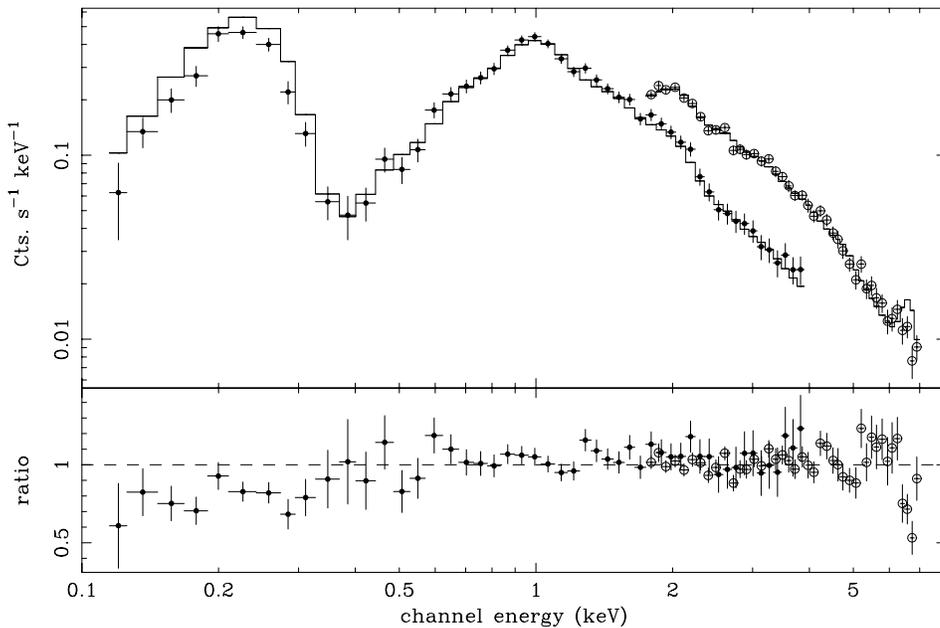|	KT_1 (keV)	KT_2 (keV)	$Z/Z_\odot$	$\frac{EM_1}{EM_2}$	flux$_{0.1\text{-}2.4\,\mathrm{KeV}}$ $\frac{\mathrm{erg}}{\mathrm{s\,cm^2}}\times 10^{-11}$	d.o.f.	χ^2
Tot. Sample	$0.90\pm^{0.18}_{0.12}$	$2.32\pm^{0.17}_{0.11}$	$0.32\pm^{0.08}_{0.06}$	0.19	4.6	87	1.8
1st Part	$0.90\pm^{0.34}_{0.19}$	$2.47\pm^{0.35}_{0.15}$	$0.33\pm^{0.11}_{0.09}$	0.13	4.8	87	1.4
2nd Part	$0.87\pm^{0.33}_{0.27}$	$2.11\pm^{0.41}_{0.20}$	$0.31\pm^{0.14}_{0.10}$	0.16	4.4	87	1.3

Fig. 2. LECS+MECS spectra for the whole data set with N_H frozen to $5\times 10^{18}\,\mathrm{cm^{-2}}$. The ratio between the data and the MEKAL two–temperature best–fit model are shown in the lower panel.

$(Z \sim 0.2\,Z_\odot)$. On the contrary, the data can not be fitted with solar abundance even with the addition of a third temperature component. This is also true if we use the II Peg photosperic abundance $(Z = 0.6\,Z_\odot)$ derived by Ottmann et al. (1998).

4. Discussion

The EXOSAT, GINGA, ROSAT, EUVE and ASCA observations of II Peg, have shown that its quiescent coronal emission is characterized by a hot plasma, with temperatures up to 20 million degrees. In particular Mewe et al. (1997) using EUVE

and ASCA data determined the differential emission measure (DEM) distribution of this source. They found a bimodal distribution for the data of both satellites, with the two peaks centered at ~ 10 and ~ 20 MK for the ASCA data. In both cases the DEM analysis gave results fully consistent with the one obtained using a two–temperature fit. Our *Beppo*SAX results are similar to the ASCA ones, we essentially find the same two temperatures (see Table 1), but the ASCA softer EM is larger than the harder one, while our harder EM is a factor of two larger than the softer one. This could be due to the decay phase of the flare, that we seem to have detected. However, our results are
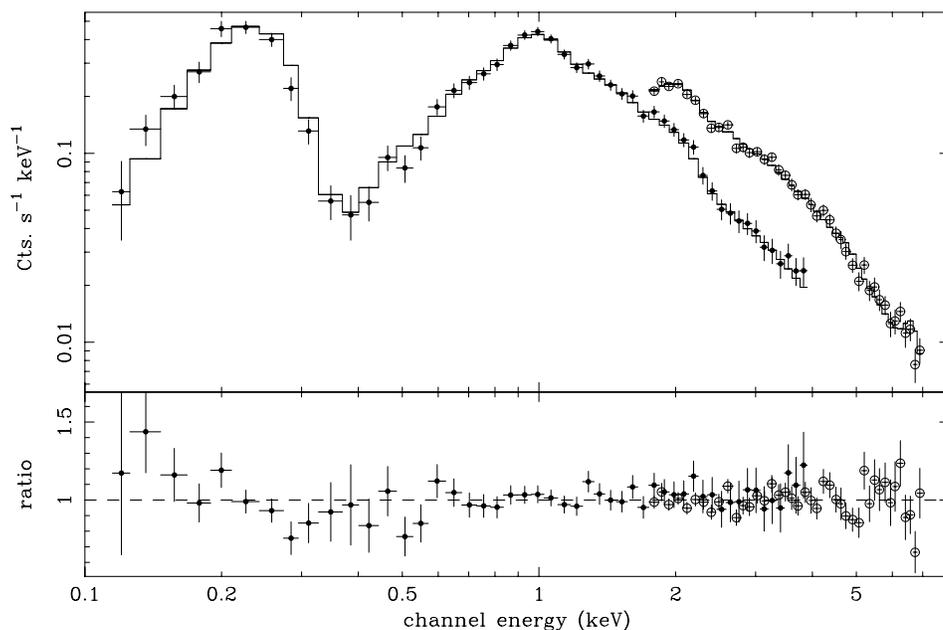
Fig. 3. LECS+MECS spectra for the whole data set with N_H free to vary. The ratio between the data and the MEKAL two–temperature best–fit model are shown in the lower panel.

also essentially in agreement with those derived by the ROSAT data analysis of Huenemoerder & Baluta (1998) once we take into account the small ROSAT energy band-width. In that case the ROSAT light curve only shows a steady linear decline from the beginning of the observation of $\sim 20\%$ without significant evidence of flare activity. The *Beppo*SAX data also show a low coronal metal abundance, significantly lower than solar, again consistent with the ROSAT (Huenemoerder & Baluta (1998), ASCA and EUVE results (Mewe et al. 1997).

ASCA observations of active coronal stars systematically yield subsolar metal abundances (White et al. 1994, White 1996; Singh et al. 1995, 1996; Tagliaferri et al. 1997, Ortolani et al. 1997, Mewe et al. 1996b, 1997), and subsolar metal abundances have also been found by other X-ray satellites (Tsuru et al. 1989; Stern et al. 1992, 1995; Ottmann & Schmitt 1996; Schmitt et al. 1996; Mewe et al. 1996b, 1997). Similar results are now obtained with *Beppo*SAX (Favata et al. 1997a, Tagliaferri et al. 1999; Pallavicini & Tagliaferri 1998; Pallavicini et al. 1999; Rodonò et al. 1999). This does not imply necessarily that these values are in contradiction with the photospheric abundances for the same stars. Indeed, for some of them they are not, but for some other stars the derived coronal metallicities are significantly lower than the photospheric values (see discussion in Tagliaferri et al. 1999 for a list of cases). The latter seems to be the case for II Peg, for which Ottman et al. (1998) from a detailed and sophisticated analysis found recently a photospheric value of [Fe/H][1] ~ -0.2, while we found a coronal metallicity that is a factor of three lower (see Table 1).

In their study, Ottmann et al. (1998) have determined the photospheric metal abundances of several active stars in order to investigate on the possible abundance stratification in stellar atmospheres. Their results for various RS CVn binaries (AY Cet, VY Ari, EI Eri, IM Peg, λ And and II Peg) show that all these stars have abundances $[Fe/H] > -0.4$. In particular, for II Peg they found [Fe/H]~ -0.2 (i.e. $Z \sim 0.6\,Z_\odot$), in contrast with a previous determination by Randich et al. (1994) who gave [Fe/H]$= -0.5$ (i.e. $Z \sim 0.3\,Z_\odot$). If the value found by Ottmann et al. (1998) is correct, we have a discrepancy by a factor ~ 3 between the photospheric and the coronal metallicities, similarly to what has been reported for other active stars (e.g. AB Dor, Mewe et al. 1996b). To explain the observed metallicity gradient two possible mechanisms are often invoked: the so called First Ionization Potential (FIP) effect and the hydrostatic equilibrium stratification.

The FIP-effect has been invoked to explain the observed abundance gradient in the Solar atmosphere. The elements with a high FIP (N, O, Ne, Ar) are underabundant in the corona, with respect H, by a factor of 3–4 compared to the photosphere. On the contrary, elements with a low FIP (Fe, Mg, Si, Ca, Na) are overabundant (Meyer 1985, Feldman & Widing 1990). In case the FIP-effect is effectively working in II Peg, we should expect that overall metallicity Z (which is essentially determined by Fe) is enhanced (and not depleted, as observed) with respect to the photospheric value. Moreover, elements such as Fe, Mg and Si, which have the same FIP ($7 \div 8\,$eV), should have approximately the same ratio between their coronal and photospheric abundances. Our *Beppo*SAX data do have not enough resolution to constrain the abundances of individual elements, but the coronal abundances derived from the ASCA and EUVE observations by Mewe et al. (1997) do not appear to confirm this expectation in the case of II Peg. In fact, whereas Fe, Mg and Si have similar photospheric abundances (Ottmann et al. 1998), the Fe and Si coronal abundances reported by Mewe et al. (1997) differ by a factor of 2. If the coronal abundances derived by us and others from X-ray observations are correct, and do not depend significantly on uncertainties on the atomic data and on the modeling (including neglected possible line opacity

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[1] [Fe/H]=log [(Fe/H)/(Fe/H)$_\odot$]

effects, cf. Schrijver et al. 1995), and if the photospheric abundances derived by Ottmann et al. (1998) are also correct, there is a clear discrepancy in II Peg between photospheric and coronal abundances. However, the FIP-effect is unlikely to be the cause for this discrepancy.

The second scenario, proposed by Mewe et al. (1997, see also van den Oord & Mewe, 1999), and widely discussed by Ottmann et al. (1998), consists of the possibility that a reduction in the metal coronal abundance is simply the effect of the establishment of hydrostatic equilibrium. The scale height for each ion depends on the mass and charge and the depletion of the coronal abundances compared to the the photospheric ones may even reach a factor within $2 \div 10$. The whole problem seems rather complex and is still lacking of a full and satisfactory theoretical treatment. However, Ottmann et al. (1998), neglecting the effect of the ion charge, conclude that for II Peg an agreement between observations and predictions for Fe, Mg and Si can be found in the sense that the correct direction of the effect is predicted.

An interesting alternative and/or complementary explanation for these observations has been proposed recently by Drake (1998). The mechanism consists in the possibility that the depletion of the coronal abundances is only apparent and actually due to the enhancement of the coronal He abundance. The gross result would be that of a lowering of the ratio between lines and continuum, just what is actually measured to derive the metal abundance from X-ray observations of stellar coronae. In stellar coronae with temperature $\sim 10^7$ K, in fact, the continuum emission is driven by inelastic collisions between electrons and H and He nuclei. He in coronae can be more abundant than in the photosphere due to a fractioning of the composition analogous at the FIP-effect (see, for instance, Meyer 1993). There is, moreover, the possibility that He nuclei are braked due to an inefficient Coulombian drag in the wind acceleration phase (see Geiss 1982). To mimic the metal abundances we derived in this paper ($Z \sim 0.2 Z_\odot$, or [Fe/H]~ -0.7) would be necessary to assume that the ratio between the He and the H coronal abundance for II Peg is more than a factor of ten higher than that in the Sun (see Fig. 1 in Drake 1998, i.e. an He abundance comparable to or higher than that of the H). We tried to fit the X-ray spectra assuming a coronal metal abundance equal to the photospheric one determined by Ottmann et al. (1998) and letting the He abundance free to vary. However, we could not find a good fit to the data in this way. Thus, this does not seem to be a valid explanation for the II Peg case.

The energy released by the flare we detected is not easy to compute. We can only derive a lower limit assuming that the beginning of the flare is coincident with the beginning of our observation. We also assume that the best-fit parameters reported in Table 1 for the first part of the observation are adequate for an average description of the spectral features of the flare. In such a case, with a minimum flare duration of ~ 10 hours the total fluence released amounts to $\sim 1.9 \times 10^{-6}$ erg cm^{-2}. With a distance of ~ 42 pc this translates in a total energy release of $\sim 4 \times 10^{35}$ erg, to be compared with the energy released by the quiescent flux of the star in the same amount of time ($\sim 3.7 \times 10^{35}$ erg). The quiescent luminosity observed by BeppoSAX is of the order of 10^{31} erg s^{-1} (see Tables 1 and 2). Indeed, the recent revision of the II Peg system distance by *Hipparcos* moved the system $\sim 50\%$ farther than previously assumed. This implies that previous estimates of luminosities and total energy release for II Peg were underestimate by a factor ~ 2. Taking this into account, the *Beppo*SAX observed luminosity is in agreement with those recorded in the previous ROSAT PSPC observation (Dempsey et al. 1993a, 1993b; Huenemoerder & Baluta 1998). The statistics of our observation eventually do not allow us to perform any time-resolved analysis and the only partial coverage of the phenomenum prevent us to try to model the flare in order to derive more flare parameters and to discriminate between different theoretical scenarios.

A new *Beppo*SAX observation of II Peg lasting 150 ks has been approved, with the aim of detecting a strong flare. However, even if a large flare is catched and modeling of the flare will become possible, this new observation will not solve the problem of the low coronal metallicities found for this source by different satellites and of their apparent discrepancy with the photospheric values. This is a topic that will better be addressed with future more sensitive, and with better spectral resolution, X-ray missions like CHANDRA, XMM and ASTRO–E. With these missions, it will also be possible to verify if the high N_H values indicated by *Beppo*SAX are real or not, and to understand their still unexplained origin.

References

Anders E., Grevesse N., 1989, Geochim. Cosmchim. Acta, 53, 197

Berdyugina S.V., Jankov S., Ilyin I. et al., 1998a, A&A 334, 863

Berdyugina S.V., Berdyugin A.V., Ilyin I., et al., 1998b, A&A 340, 437

Boella G., Butler R., Perola G.C., et al., 1997a, A&AS, 122, 299

Boella G., Chiappetti L., Conti G., et al., 1997b, A&AS, 122, 341

Dempsey R.C., Linsky J.L., Fleming T.A., Schmitt J.H.M.M. 1993a, ApJS, 86, 599

Dempsey R.C., Linsky J.L., Fleming T.A., Schmitt J.H.M.M. 1993b, ApJ 413, 333

Doyle J.G., Byrne P.B., van den Oord G.H.J., 1989, A&A 224, 153

Doyle J.G., van der Oord G.H.J., Kellet B.J., 1992, A&A 262, 533

Drake J.J., 1998, ApJ 496, L33

Favata F., 1998, Nuclear Physics B (Proc. Suppl.) 69, 23

Favata F., Mineo T., Parmar A.N., Cusumano G., 1997a, A&A 324, L41

Favata F., Mewe R., Brickhouse N.S., et al., 1997b, A&A 324, 37

Favata F., Maggio A., Peres G., Sciortino S. 1997c, A&A 326, 1013

Feldman U., Widing K.G., 1990, ApJ 363, 292

Fiore F., Guainazzi M., Grandi P., 1999, Cookbook for NFI *Beppo*SAX Spectral Analysis v. 1.2, available at www.sdc.asi.it

Frontera F., Costa E., Dal Fiume D., et al., 1997, A&AS, 122, 357

Geiss J., 1982, Space Sci. Rev., 33, 201

Gehrels N., 1986, ApJ 303, 336

Giommi P., Fiore F., 1997, 5th *International Workshop on Data Analysis in Astronomy*, Erice, Italy, V. Di Gesù, M.J.B. Duff, A. Heck, M.C. Maccarone, L. Scarsi, H.U. Zimmermann (eds.), Word Scient. Publ., p. 73

Haisch B.M., Rodonò M. 1989, Solar Physics, 121, 512

Huenemoerder D., Baluta C. 1998, ASP Conf. Ser., 154, 1070

Jenkins L.F. 1963, in General catalogue of trigonometric stellar parallaxes (New Haven: Yale University Observatory)

Meyer J.P., 1985, ApJS, 40, 1

Meyer J.P., 1993, in Origin and Evolution of the Elements, ed. N. Prantzos, E. Vangioni-Flam, & M. Cassé (Cambridge: Cambridge Univ. Press), 26

Mewe R., Kaastra J.S., Liedahl D.A., 1996a, *Legacy* The Journal of the HEASARC, 6, 17

Mewe R., Kaastra J.S., White S.M., Pallavicini R., 1996b, A&A 315, 170

Mewe R., Kaastra J.S., van den Oord G.H.J., Vink J., Tawara Y., 1997, A&A 320, 147

O'Neal D., Saar S.M., Neff J.E., 1998, ApJ 501, L73

Ortolani R., Maggio A., Pallavicini R., et al., 1997, A&A 325, 664

Ottmann R., Pfeiffer M.J., Gehren T., 1998, A&A 338, 661

Ottmann R., Schmitt J.H.M.M., 1996, A&A 307, 813

Pallavicini R., Tagliaferri G., 1998, Nuclear Physics B (Proc. Suppl.) 69, 29

Pallavicini R., Tagliaferri G., Maggio A., 1999, Adv. Space. Res., in press

Paresce F., 1984, AJ, 89, 1022

Parmar A.N., Martin D.D.E., Baudaz M., et al., 1997, A&AS, 122, 309

Parmar A.N., Oosterbroek T., Orr A., 1999, A&AS, 136, 407

Randich S., Giampapa M.S., Pallavicini R., 1994, A&A 283, 893

Raymond J.C., Smith B.W., 1977, ApJS, 35, 419

Rodonò M., Pagano I., Leto G., et al., 1999, A&A, in press

Schmitt J.H.M.M., Stern R.A., Drake J.J., Kürster M., 1996, ApJ 464, 898

Schrijver C.J., Mewe R., van den Oord G.H.J., Kaastra J.S. 1995, A&A 302, 438

Schwartz D.A., Garcia M., Ralpha E., Doxsey R.E., Johnston M.D., et al., 1981, MNRAS 196, 95

Singh K.P., Drake S.A., White N.E., 1995, ApJ 445, 840

Singh K.P., White N.E., Drake S.A., 1996, ApJ 456, 766

Stern R.A., Lemen J., Schmitt J.H.M.M., Pye J.P., 1995, ApJ 444, L45

Stern R.A., Uchida R.A., Tsuneta S., Nagase F., 1992, ApJ 400, 321

Tagliaferri G., Covino S., Cutispoto G., Pallavicini R., 1999, A&A, in press

Tagliaferri G., Covino S., Fleming T.A., et al 1997, A&A 321, 850

Tagliaferri G., White N.E., Doyle J.G., et al., 1991, A&A 215, 161

Tsuru T., Makishima K., Ohashi T., et al., 1989, PASJ 41, 679

van den Oord G.H.J., Mewe R., 1999, in preparation

Vogt S.S., 1981, ApJ 247, 975

White N.E., Arnaud K., Day C., et al., 1994, PASJ 46, L97

White N.E., 1996, ASP Conf. Ser., 109, 193