The *XMM-Newton* view of Plaskett's star and its surroundings

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Abstract: *XMM* data of Plaskett's star (HD 47129) are used in order to analyse its X-ray spectrum and variability and hence to derive further constraints on the wind interaction in this early-type binary (O6 I + O7.5 I) system. Combining the information provided by the EPIC and RGS instruments, we find that the X-ray spectrum of Plaskett's star is dominated by thermal plasma at lower energies, whereas the higher energy part (> 3 keV) could probably best be represented by a featureless power law component since we do not detect a significant Fe-K line. Our tests also suggest that an overabundance in nitrogen by a factor ~ 6 might be indicated to best represent the RGS spectrum. On the other hand, 71 X-ray sources have been detected in Plaskett's star field of view and most of them have counterparts in near-IR colours that are consistent with slightly reddened main-sequence objects. Actually, a sizeable fraction of the X-ray sources in the EPIC images could be either foreground or background sources with no direct connection to HD 47129.

1 Introduction

HD 47129 has first been studied by J.S. Plaskett in 1922. For this reason, HD 47129 is commonly referred to as Plaskett's star. The star is actually a spectroscopic binary system and it is believed to belong to the Mon OB2 association (at a distance of 1.5 kpc).

The first spectrum was obtained in 1921 and allowed Plaskett to assign an O5e spectral type. The spectrum of the fainter component (the secondary) appeared to be similar to the primary's one, but weaker and more diffuse. As no variations in the brightness of this system were observed, the lack of photometric eclipses renders the determination of the orbital inclination rather difficult. Plaskett estimated the diameters of the stars to be 20 and 18 $R_\odot$ and their separation to be about 128.5 $R_\odot$. Then the maximum possible inclination would be 73°, which leads to masses of 86 and 72 $M_\odot$ for the primary and secondary respectively, corresponding to the most massive stars in a binary known at that time.

Bagnuolo et al. (1992) analysed *IUE* data and found a mass ratio $q = 0.847 \pm 0.12$ (the secondary being more massive than the primary). Assuming an inclination of 70°, the mass of the primary would then be equal to 42.5 $M_\odot$, and the mass of the secondary would be equal to 51.0 $M_\odot$. These authors used a tomographic technique to separate the spectra of the two

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	$M/M_{\odot}$	Spectral type	T_{eff} [K]	log $L/L_{\odot}$	$R/R_{\odot}$	$V sini$ [km/s]
Primary	42.2	O7.5 I	35,100	5.80	21.5	75
Secondary	51.0	O6 I	38,400	5.57-5.94	13.8-21.1	310

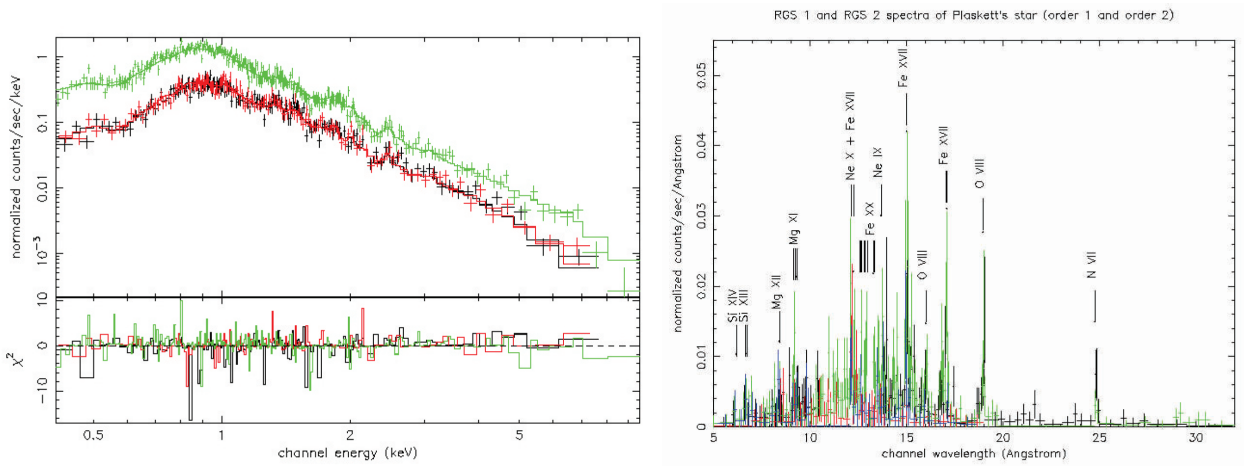
Table 1: Characteristics of Plaskett's star (Bagnuolo et al. 1992)

components of the system and found spectral types of O7.5 I and O6 for the primary and for the secondary, respectively.

XMM data of Plaskett's star are used here in order to analyse its X-ray spectrum and variability and hence to derive further constraints on the wind interaction in this binary system. The observation was made on 16th March 2003 for a total exposure time of 21.621 ks. The thick filter was used to reject optical light, and the operating mode was the full window mode for all three EPIC instruments.

2 Spectral analysis

The spectra were fitted with various models using the *xspec* software. We tested several combinations of absorbed optically thin thermal plasma (`mekal`) and powerlaw models. The choice of these model components is motivated by the fact that the X-ray emission of massive stars can (to first approximation at least) be represented by an optically thin thermal plasma (e.g. Rauw et al. 2002, De Becker et al. 2004). The power law component is added to account for a possible inverse Compton tail that could be produced by relativistic electrons accelerated in the wind collision zone. In all combinations, the interstellar absorption along the line of sight of Plaskett's star was frozen at a column density of hydrogen equal to 0.15×10^{22} cm^{-2} (Diplas & Savage 1994). The statistically best fit to the EPIC data was achieved for a model `ISM` $*$ [`mekal` + (`wabs` $*$ `mekal`) + (`wabs` $*$ `powerlaw`)] (see Fig. 1(a)). The softer mekal component



(a) (b)

Figure 1: (a) EPIC spectra of Plaskett's star from 0.4 kev to 10 keV along with the best fit model. MOS 1 is in black, MOS 2 in red and PN in green. (b) RGS spectra of Plaskett's star. The first order of RGS 1 is in black, and its second order is in red. The first order of RGS 2 is in green, and the second order in blue.

of this model has a temperature of 0.64 keV, quite typical of the intrinsic X-ray emission of O-type stars. The other mekal component has a temperature of 1.25 keV. Although it is harder than expected for shocks intrinsic to the winds, this value is not as extreme as the temperature seen for several other colliding wind binaries. Finally, the power law component has a photon index of 2.6. This value is quite large, but is reminiscent of the results obtained for other O-star binaries (e.g. HD 159176, De Becker et al. 2004).

The N VII Lyα line at 24.8 Å is quite intense in the RGS spectra (see Fig. 1(b)) despite the large ISM absorption. This prompted us to test also models with a variable nitrogen abundance. When only EPIC data are fitted, no improvement is observed and the nitrogen tends to disappear. Actually, the power law component with $\gamma \sim 2.6$ seems to account for the bump at 0.5 keV in the EPIC spectra. On the other hand, for all models tested, when only the RGS data are fitted, the fit yields a nitrogen overabundance by a factor ~ 6 compared to solar. With its superior spectral resolution, the RGS allows us to see that the 0.5 keV feature is actually due to N VII line emission rather than continuum. This suggests that, if a power law component is indeed present in the X-ray spectrum of HD 47129, it is probably not as steep as indicated by the EPIC fits.

3 Surroundings of Plaskett's star

71 serendipitous sources have been detected in Plaskett's star field of view. Among these sources, only a fraction corresponds to known objects. The positions of these X-ray sources have been compared to three existing catalogues in order to determine whether they have a counterpart at other wavelengths: the GSC (Guide Star Catalogue), USNO (United States Naval Observatory) and 2MASS (Two MicronsAll Sky Survey). 37 sources have at least one counterpart in each of the three catalogues, and for 32 of them this counterpart is unique. On the other hand, there are 25 sources for which no counterpart could be found in any of the three catalogues.

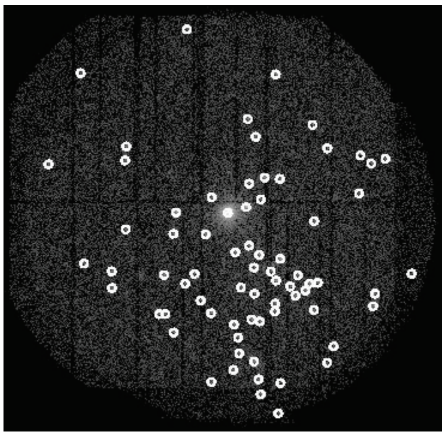


Figure 2: Detection of 71 secondary sources in the EPIC field of view around Plaskett's star.

The open cluster NGC 2244, situated in the Rosette Nebula, forms the nucleus of the Mon OB2 association. Plaskett's star lies at an angular distance of 107 arcmin from the core of NGC 2244. Assuming that Plaskett's star is situated at the same distance from Earth as NGC 2244 (1.5 kpc, Berghöfer & Christian 2002), they are separated by at least 46.7 pc, which means that HD 47129 is too far from the cluster to belong to it. Furthermore, the peculiar velocity of the star is rather low, making it unlikely that the binary formed in the cluster and was ejected through subsequent dynamical interactions.

On statistical grounds, a sizeable fraction of the X-ray sources in the field of view could be either foreground or background sources. On the other hand, Berghöfer & Christian (2002) found an important number of X-ray bright pre-main sequence stars in NGC 2244. Although HD 47129 is probably not a member of NGC 2244, one could nevertheless expect a priori that a fraction of the X-ray sources near the star might be pre-main sequence objects. However, there is no clear excess of X-ray sources that could reveal the presence of a sizeable population of low-mass pre-main sequence stars in the surroundings of Plaskett's star.

This fact is confirmed by the $J-H$ vs. $H-K$ diagram derived from the 2MASS data and shown on Fig. 3. The classical T Tauri stars have circumstellar disks that produce an infrared excess and they are thus mostly found towards the right of the reddening band (Meyer et al. 1997). We can see on Fig. 3 that only one source of Plaskett's star field is actually a good candidate for a classical T Tauri star.

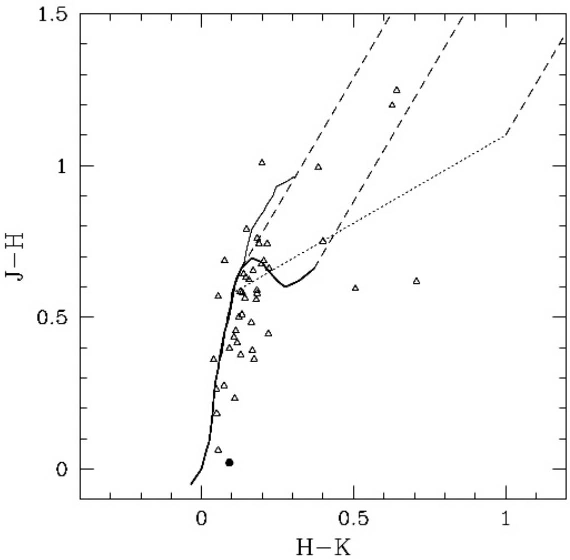


Figure 3: JHK colour-colour diagram of the 2MASS counterparts of the X-ray sources in the EPIC field of view around HD 47129. The solid bold line yields the intrinsic near-IR colours of main sequence stars while the other solid line is the locus of unreddened giants. The dotted straight line yields the locus of dereddened colours of classical T Tauri stars, whereas the dashed lines form the reddening band for normal dwarf stellar photospheres. Plaskett's star is indicated by a filled circle.

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