PRECATACLYSMIC VARIABLES: OBSERVATIONAL DATA AND MODELS

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ABSTRACT. We summarize the first results of modelling light curves of precataclysmic binaries with strong reflection effect. Our approach is based upon modified Napier's technique and explicit computation of emergent radiation intensity using the source functions given by Strittmatter and Sobieski.

Key words: Planetary nebulae, precataclismic binaries

Introduction

Precataclysmic binaries (PCB) is a small group of detached close binary systems, which are observed at the centre of planetary nebula, consisting of a hot white dwarf or a subdwarf accompanied by an essentially unevolved low mass cool companion $M_2 \leq 1M_\odot$. PCB orbital periods are so short (typically less than two days) that they can only have been formed via a common envelope evolution (see, for instance, Bond et al 1992, Ritter 1986).

Recently we have started a systematic reevaluation of the existing observational methods of analysis hitherto applied to PCB-s. Our current activity in this field has been motivated by the following considerations:

I) Although PCB-s are detached binaries, reflection effect may not be the only first order proximity effect caused by irradiation from the hot component. Soft X-ray and UV radiation should considerably alter the structure of chromosphere and corona of the cool companions. Thus, significant departures from the standard mass radius relation valid for main sequence stars (and often used in the estimates of the relevant evolutionary time-scales) may be expected.

II) Detailed data on X-ray and EUV fluxes from hot primaries impinging upon atmospheres of the low mass cool companions are still lacking. Modelling the properties of evaporative wind for this class of objects and its observable manifestations can shed some light upon the energy distribution of the hot irradiating primaries (or at least set upper limits for the fluxes in these spectral ranges).

III) There are still uncertainties in our knowledge of the physical parameters for the component stars involved in PCB (among others, the velocity of axial rotation and radii of cool companions). Available statistics of well studied PCB-s is still far from being adequate (with the exception of BE UMa, see Ferguson and James, 1994). Yet in the existing catalogues (Ritter, 1986, Bond et al, 1992) precataclysmic binaries present themselves as rather heterogeneous group of objects. Specifically it remains to be clarified what is the relation between PCB, Abel-35 type nuclei and recently discovered with the aid of *ROSAT* EUV all-sky survey wide binary systems like *2REJ 044+093* consisting of a hot white dwarf and an ultra-rapidly rotating K-dwarf (Jeffries and Stevens, 1995).

Here we report the first results of our investigations.

We have elaborated a method that would permit us to construct light curves of these systems caused by the reflection effect. In absence of eclipses, this effect is the main factor causing periodic luminosity variations of a binary. Conservative estimates indicate that such systems should constitute 10-15 % of all precataclysmic binaries.

In the present work the improved Napier's algorithm (Napier, 1968) is used. Intensity of the emerging radiation is calculated using the standard approach of the radiation transfer theory. For determination of the temperature distribution in the photosphere two methods are alternatively applied: those of Sobieski 1965 and Strittmatter, 1974. Absorption coefficients are taken into account separately for 3 cases: absorption by neutral hydrogen, by H^- ions and the grey case. Calculations of the absorption coefficients are performed according to the formulae given by Grey, 1976; the Planck mean absorption coefficient is used. The entire luminosity received from the cool companion is calculated by integration of the emerging radiation over its disk; it is the sum of contributions from the illuminated and unilluminated portions of the disk. The light curve is normalized with the total brightness of the system in the minimum phase.

According to the foregoing considerations we have composed a set of computer programs in *Turbo Pascal 7.0*. It enables one to construct light curves of detached binary systems. As initial parameters it receives fractional radii of the components, their effective temperatures and the orbit inclination angle. An ab-

sorption coefficient and a method for determination of temperature distribution must be specified also. If the Strittmatter's method is used, it is necessary to specify values of the coefficients α and q, α being absorption albedo and q being the ratio of optical depths in the X-ray and visible range.

Our model is based upon the following main assumptions: a) the validity of the local thermodynamic equilibrium in the photosphere of cool component; b) absorption by only one agent; c) constancy of the monochromatic to mean absorption coefficient ratio within the photosphere; d) the hot star irradiates as the absolutely black body; e) the components are spherical and there are no other effects affecting the light curve except for the reflection effect.

With the use of the improved method we have modelled the light curves of the detached binary *EC11575-1845*. In the paper of Chen et al (1995), the orbital period of 7.86 days has been established for this system and 5 light curves for different photometric bands are given. There are no eclipses in the system and its variability is caused by the reflection effect. To simplify the calculations, we have approximated the observed light curves by the Fourier series. Thereafter a number of sets of parameters modelling the observational data were found. Some of them were refined later. The agreement between the observed and the calculated data was quite satisfactory. In the Fig.1 two theoretical light curves are given for the I-band obtained with the aid of the two methods and with different absorption coefficients. Points represent the observational data.

The analysis of the temperature distributions in the heated photosphere indicates that in some cases a temperature inversion may be present. Its existence is predicted both by the Sobieski's and by the Strittmatter's method. Due to this effect in the regions where the inversion occurs, the limb-darkening coefficient behaves peculiarly: the emerging radiation tangent to the surface may be more intensive then the radiation along the normal (limb-brightening).

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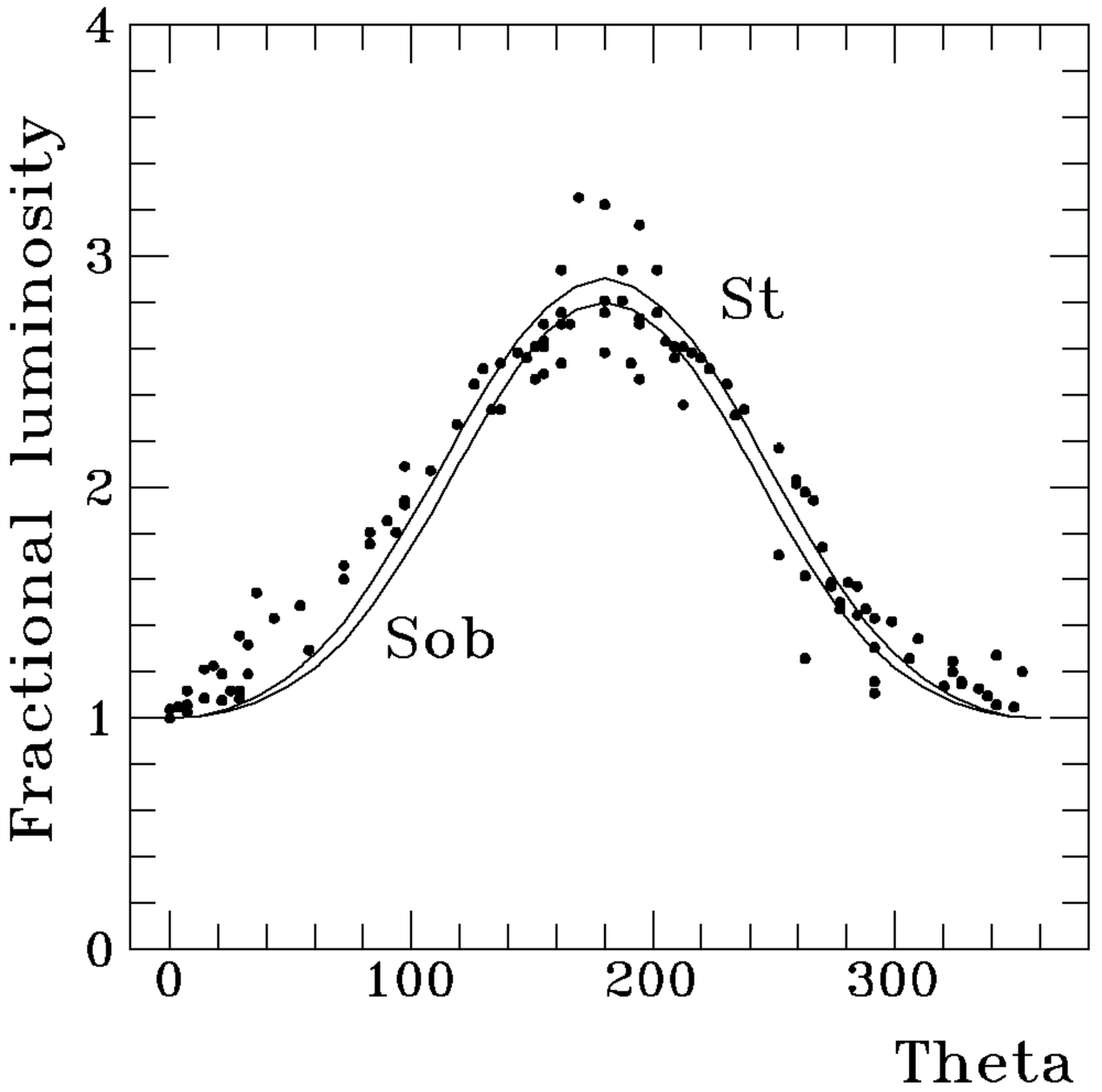

Figure 1. The theoretical light curves of the system *EC11575-1845* in the I-band calculated with use of different methods (solid lines). The points present the observational data. The curve marked with **St** has been modelled using the Strittmatter's method with H^- ion as the absorption agent. The set of parameters is as follows: $a_1 = 0.021, a_2 = 0.110, T_1 = 125000K, T_2 = 3500K, q = 9.5, \alpha = 0.50$. The curve marked with **Sob** corresponds to the Sobieski's method in the grey case. $a_1 = 0.038, a_2 = 0.225, T_1 = 108000K, T_2 = 3500K$. Here a is a stellar radius in units of semi-major axis of relative orbit, T its effective temperature. The index 1 refers to the illuminating, 2 to the illuminated star.

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