SOFT X-RAY IMAGING OF TY Pyx BINARY SYSTEM

Possible Presence of Interconnecting Stellar Loop

M. SIARKOWSKI[1], J. SYLWESTER[1] and P. PREŚ[2]

[1] *Space Research Center, Polish Academy of Sciences, Wrocław, Poland*

[2] *Astronomical Institute, Wrocław University, Wrocław, Poland*

Abstract. Using a new 3D deconvolution technique we analyze the X-ray light curve of TY Pyx eclipsing binary to model the corona around the system. Our result indicates the possible presence of an interstellar loop connecting the stars.

Key words: RS CVn Binaries – Eclipsing Binaries – X-Rays – Coronae

1. Introduction

TY Pyx (HD 77137) is a 3.2 day eclipsing ($i = 88°$) RS CVn binary system. It consists of two similar solar-like stars (G2-5 V) with radii R=1.59 $R_\odot$ and R=1.68 $R_\odot$, respectively, separated by 12.25 $R_\odot$. This system was observed by EXOSAT low-energy imaging telescope, LEIT (0.05-2 keV), and medium energy proportional counter, ME (1-30 keV), during one complete orbital binary period. The obtained soft X-ray (LE) light curve is clearly modulated due to eclipses in the binary system. This modulation has been interpreted by Culhane *et al.* (1990) in order to localise X-ray sources in the corona of TY Pyx. Their results of the modelling show that the observed X-ray lightcurve can result from eclipsing of two emission regions, opposing each other on the inward faces of the two stars (i.e., having longitudes 0° and 180°). The authors assumed that the vertical size of emitting structures is 0.01 $R_\odot$, similar to the size found in the earlier modelling of AR Lac system, however the possibility that the regions form a loop joining two stars had not been excluded.

In this paper we reanalyze the modulation of TY Pyx LEIT light curve using a new 3-dimensional iterative deconvolution technique (Siarkowski, 1992). This new method allows to determine the distribution of the soft X-ray emission in three dimensions, without making a priori assumptions about a localisation, number or size of the emitting structures. The obtained results indicate for the presence of the bulk of plasma in between the two stars. The spatial distribution of the emission indicates for the presence of the loop structure interconnecting the stars as was first suggested by Culhane *et al.* (1980).

IAU Colloq. 144 "Solar Coronal Structures", V. Rušin, P. Heinzel, & J.-C. Vial (eds.), 207– 209

2. The Observations

TY Pyx was observed by EXOSAT low-energy (LE) imaging telescope and medium energy (ME) proportional counter on 1985 November 21-24 (Culhane *et al.*, 1990). Herein we use background subtracted light curves from the paper by Culhane *et al.* (1990). During observation two significant decreases in LE counting rate occurred at the primary (phase 1.0) and the secondary (phase 1.5) eclipses. Detailed description of the observation is given by Culhane *et al.* (1990).

The presence of eclipses on LE light curve suggests the existence of localised X-ray emitting regions in the binary system. We have interpreted this observed flux modulation to reconstruct distribution of soft X-ray emission within the system.

3. The Corona of TY Pyx

We have performed 3D deconvolution of the observed LE lightcurve. In the present case we have carried out iterative calculations with a grid size of 0.3 $R_\odot$, this means we have divided the emitting volume around TY Pyx into $97 \times 57 \times 6 = 33174$ elementary cubes. We have assumed for simplicity that the orbital inclination i is 90°. This simplifies the problem making the occultation array symmetric with respect to the orbital plane of the system. Accordingly, we have performed calculations for the upper half-space of the system only with z varying from zero to 1.68 $R_\odot$.

The obtained results are shown in Fig. 1. The left part of this figure represents the image of the corona as viewed from above the orbital plane. The middle part shows a side view of the system for phase angle of 0.25 (90°). In the right part of the figure observed and calculated lightcurves are overlaid. The iteration process has been stopped when the reduced value of χ^2 decreased to 1.

Three dominant structures are seen on the obtained distribution: two active regions, one on the primary (upper star) and one on the secondary (lower star) and an elongated feature between both stars. The active regions are located at longitudes $\sim 320°$ and $\sim 230°$ respectively. The elongated bright structure between stars has a maximum of intensity near the center of gravity of the binary and resembles the loop-like structure possibly connecting the stars.

Contrary to method used by Culhane *et al.* (1990), the method used here offers a possibility of investigating the structures for which intensity increases with height above star surface (like in solar coronal loops). Culhane *et al.* predicted the presence of two emission regions pointing at each other on the inward faces of the two stars. Our solution predicts presence of two active regions similar to Culhane's solution and additionally a loop structure possibly connecting both stars.

We have performed similar calculations for lightcurves corresponding to different data gathering times. In all cases the solutions obtained were similar to these presented in Fig. 1. Test calculations show that there may exist distributions of the emission

other than that shown in Fig. 1 that result in the observed modulation. These solutions correspond to the situation where the emitting structures are located on the outward sides of stars at the distances 3-5 $R_\odot$ from the stellar surfaces.

Our results seem to constitute the first confirmation of the existence of a large ($\sim$10 $R_\odot$) interconnecting stellar loop in late type binaries. Reconnection of the magnetic fields of the two active stars and reconfiguration of the photospheric magnetic loops into the inter-stellar flux tube was discussed first by Uchida and Sakurai (1984).

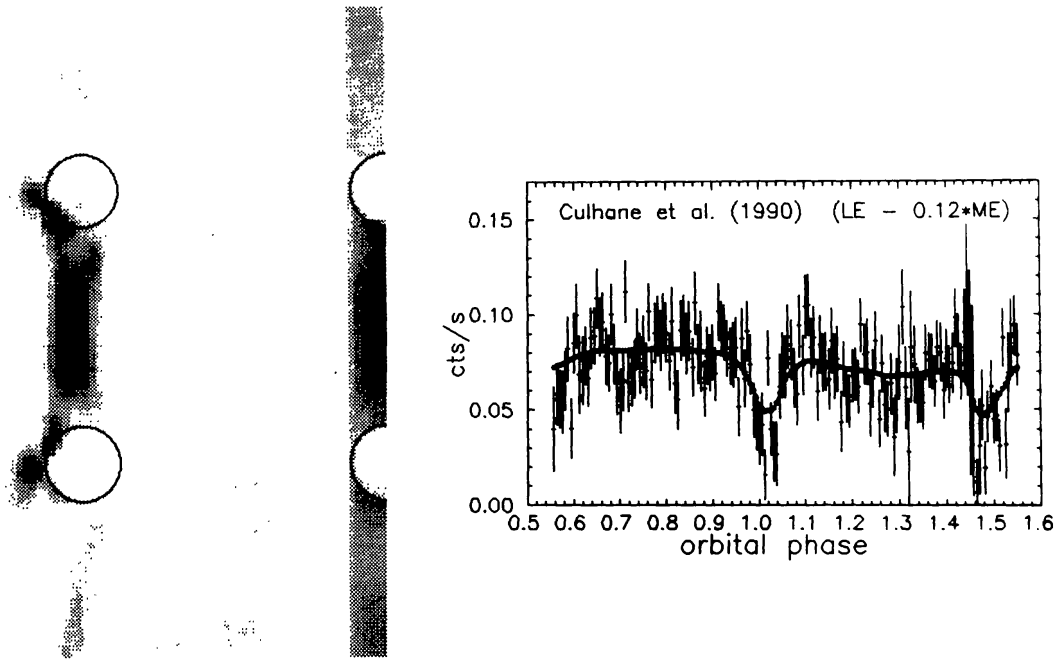

Figure 1. From the left: the top and side view of TY Pyx corona (as described in text). At the right the observed (with 1σ error bars) and calculated light curves are compared.

Acknowledgements. This work was supported by Polish State Committee for Scientific Research grant No 2 2110 92 03.

References

Culhane, J. L., White, N. E., Shafer, R. A., and Parmar, A. N.: 1990, *Mon. Not. R. Astron. Soc.* **243**, 424

Siarkowski, M.: 1992, *Mon. Not. R. Astron. Soc.* **259**, 453

Uchida, Y. and Sakurai, T.: 1984, in *Activity in Red Dwarf Stars*, eds.: P. B. Byrne, M. Rodonò, D. Reidel, Dordrecht, 629