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Applying the Steepest Descent Method with BINSYN on RY Per Photometry

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Abstract. Recent studies of the Algol-type binary RY Per presented strong evidence that there is an accretion disk around the primary in the system. We used new UBV photometry from Hvar Observatory and the BINSYN software package in order to determine the basic parameters of the disk. The search for the best parameter set was performed with a fully automated steepest descent method. The resulting disk is large and visible at all orbital phases. Somewhat surprising is the large mass transfer rate which should be tied with, currently unreported, secular period changes.

Keywords. binaries: eclipsing, stars: emission-line, Be, stars: individual (RY Per)

RY Per (HD 17034) is one of the most massive Algol binaries. Olson & Plavec (1997) determined temperatures, masses and radii of both components. They also presented strong evidence for ongoing mass transfer and the existence of circumstellar matter, although their photometric solution does not contain the disk.

More recently Barai *et al.* (2004) were able to determine radial velocities of the primary in UV spectra. They also presented a time variable but persistent disk model by analyzing Hα profiles.

In this work, we will mainly focus on obtaining more information about the accretion disk and related mass transfer from new UBV photometry.

The observations consist of 426 data points in each of the three filters. All measurements were transformed to the standard Johnson UBV system. We adopted the ephemeris derived by Olson & Plavec (1997): $T_0 = \mathrm{HJD}2441655.780 + 6.863569E$.

For light curves analysis of the accretion disk system, we used BINSYN (Linnell & Hubeny 1996). The steepest descent method was used for parameter optimization (see Sudar *et al.* 2011). The geometry of the accretion disk in BINSYN is given by the vertical thickness of the disk, H_V, outer radius of the disk, R_A, and inner radius of the disk, R_B. We allowed for convergence of the first two parameters, while the last one was fixed to the radius of the primary.

The mass transfer rate, $\dot{M}$, determines the temperature profile of the disk's face (cf. e.g. Pringle 1981) and was also allowed to converge. The only other parameter which wasn't fixed was the polar temperature of the primary, T_1; others were taken from previous studies (Olson & Plavec 1997 and Barai *et al.* 2004).

The best fit solution was sought simultaneously in all 3 filters. After several convergence runs, we obtained the best fit paramaters shown in Table 1. The resulting light curves are presented in Fig. 1, and a view of the system at phase $\phi = 0.5$ is shown in Fig. 2. It is readily observable that the disk is visible at all phases, which is in agreement with observed Hα and UV emission.

On the other hand, it is rather surprising that the mass transfer rate is so large. In a similar system, UX Mon (Sudar *et al.* 2011), it was found that a smaller transfer rate would cause a secular period change, which should most evidently manifest itself in the $O - C$ diagram of times of primary minima.

Table 1. Best fit values of converged parameters.

Param.	Value
H_V	$1.51 \pm 0.50\ R_\odot$
R_A	$14.12 \pm 1.00\ R_\odot$
$\dot{M}$	$11.31 \pm 0.50\ \mu M_\odot yr^{-1}$
T_1	16702 ± 1000 K

The errors were estimated from several convergence runs.

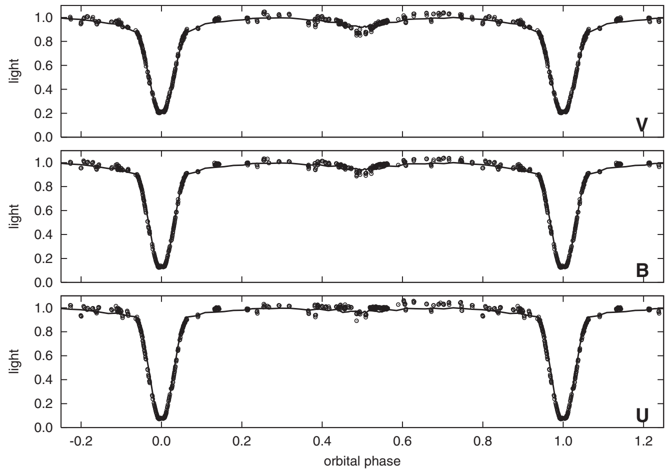

Figure 1. Observed data in UBV filters and their best fit light curves.

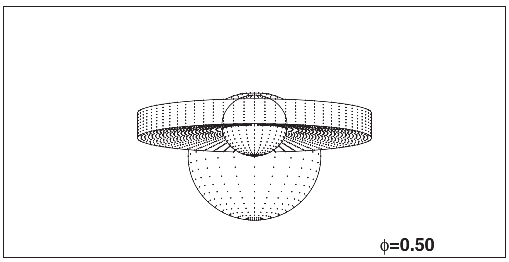

Figure 2. View of the system during secondary minimum.

References

Barai, P., Gies, D. R., Choi, E., Das, V., Deo, R., Huang, W., Marshall, K., McSwain, M. V., Ogden, C., Osterman, M. A., Riddle, R. L., Seymour, Jr., J. L., Wingert, D. W., Kaye, A. B., & Peters, G. J. 2004, *ApJ*, 608, 989

Linnell, A. P. & Hubeny, I. 1996, *ApJ*, 471, 958

Olson, E. C. & Plavec, M. J. 1997. *AJ*, 113, 425

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