SY Mus – search for physical parameters

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Since Annie J. Cannon separated the new type of objects based on their spectra, symbiotic stars have become widely analyzed as binary stars. In our work we focus on describing one of them, i.e. SY Mus. It is an eclipsing symbiotic system composed of a white dwarf (WD) and a red giant (RG), located in the southern sky. With the use of observational data in the infrared (IR) bands, we determined physical parameters of the object, such as masses and radii. We used PHOEBE tools to model all the observations.

1 Introduction

Symbiotic stars are an extremely important element in understanding the evolution of binary stars. Characteristics of these objects, all their physical and orbital parameters as well as their stage of evolution allow to refine our knowledge about these stars. We chose the symbiotic star of the southern sky, SY Muscae, well known in the literature, to improve its characteristics. With the simultaneous use of old and new observations, we aimed at better understanding properties of this type of objects. This is a system, composed of a WD and a RG, with a high inclination which allowed us to observe ellipsoidal changes in the IR related to the shape of the giant as well as eclipses.

2 Early analysis

We have reviewed the literature to learn the known parameters of the object before modeling. One of the best defined parameters is the orbital period, $P = 624.5\,\mathrm{d}$ (Rutkowski et al., 2007). Other parameters were not defined so clearly, thus during our work we focused on determining all of them, with the aim to find masses of components, their radii, separation, and inclination of the system. Based on the literature, we set initial values for a number of PHOEBE's parameters[1], namely separation between objects, $a = 350\,\mathrm{R}_\odot$ (Rutkowski et al., 2007), inclination $i = 88.8^\circ$ (Rutkowski et al., 2007), effective temperature of RG as 3 400 K (Mikołajewska et al., 2014), effective temperature of WD as 100 000 K (Skopal, 2005), metallicity of RG as [Fe/H]$= -0.15$ (Gałan et al., 2016), and systemic velocity as $13.0\,\mathrm{km\,s}^{-1}$ (Schmutz et al., 1994). In PHOEBE code we set the *unconstrained binary system* model.

We used the photometry in four infrared bands from 0.75 m telescope at SAAO (South African Astronomical Observatory), which is on the photometric system defined by Carter (1990). Errors are less than 0.03 mag in *J, H* and *K* bands, and less

[1] http://phoebe-project.org/1.0

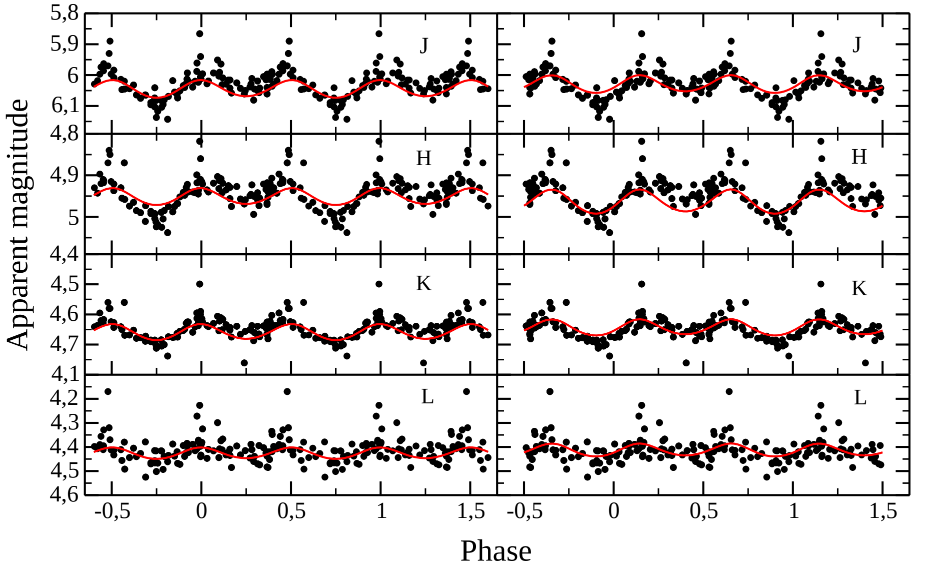

Fig. 1: The comparison of two models with reversed mass ratios, i.e. $q_1 = 2.4$ (left) and $q_2 = 0.38$ (right). Data in four bands J, H, K, L are given by black dots and fitted curves – by red lines.

than 0.05 mag in L-band. The radial velocity (RV) data are taken from Fekel et al. (2017).

Two training approaches were used to get parameters. First, we set the mass ratio, q, as secondary over primary star, and second, as the opposite. Fig. 1 shows four IR lightcurves (LC) for both the mass ratios, $q_1 = 2.4$ in the left panels and $q_2 = 0.38$ in the right panels.

3 The results

We found approximate values of basic system's parameters, see Tab.1. Results from both models are similar and comparable to those in the literature. LC and RV (Fig.2 left) curves in both approaches provide similar results. The fit seems to be better for RV in the case of the first model, however, for LC, especially in the H-band, the second model seems better. Additionally, the appearance of the system is shown where a slight flattening of the giant is visible (Fig. 2 right).

4 Future plans

In the next stages of our work we will include additional photometric and spectroscopic data. Next, we will estimate uncertainties of the solution. This work is in progress.

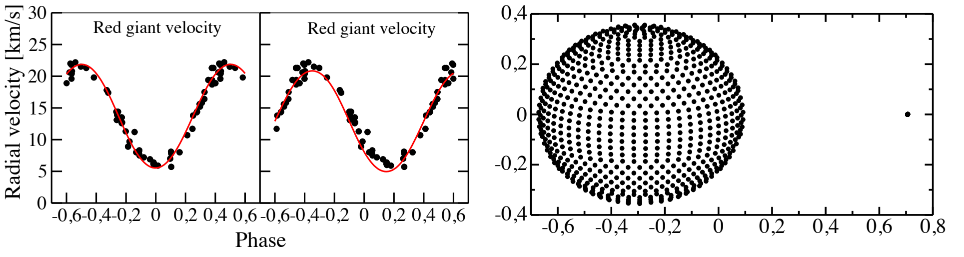

Fig. 2: Left panels: RV for q_1 (left) and q_2 (right). Data points in the IR for RG are given in black, and the fitted curve by red line. Right panel: System's shape showing the relative distances of components from the center of mass.

	$q_1 = M_\mathrm{g}/M_\mathrm{h} = 2.4$	$q_2 = M_\mathrm{g}/M_\mathrm{h} = 0.38$
i [°]	75	88
a [$\mathrm{R}_\odot$]	357.5	360
M_g [$\mathrm{M}_\odot$]	1.11	1.17
M_h [$\mathrm{M}_\odot$]	0.46	0.44
R_g [$\mathrm{R}_\odot$]	131.22	143.93
R_h [$\mathrm{R}_\odot$]	0.10	0.14
V_0 [$\mathrm{km\,s^{-1}}$]	13.7	12.9
P [d] (fixed)	624.5	624.5

Table 1: Two possible solutions of our modeling of the SY Mus star.

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