

# Modelling of an Eclipsing RS CVn Binary: V405 And

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**Abstract.** V405 And is an ultrafast-rotating ( $P_{\text{rot}} \approx 0.46$  days) eclipsing binary. The system consists of a primary star with radiative core and convective envelope, and a fully convective secondary. Theories have shown that stellar structure can depend on magnetic activity, i.e., magnetically active M-dwarfs should have larger radii. Earlier light curve modelling of V405 And indeed showed this behaviour: we found that the radius of the primary is significantly larger than the theoretically predicted value for inactive main sequence stars (the discrepancy is the largest of all known objects), while the secondary fits well to the mass-radius relation. By modelling our recently obtained light curves, which show significant changes of the spotted surface of the primary, we can find further proof for this phenomenon.

**Keywords.** stars:activity, binaries: eclipsing, stars: fundamental parameters, stars: late-type, stars: spots

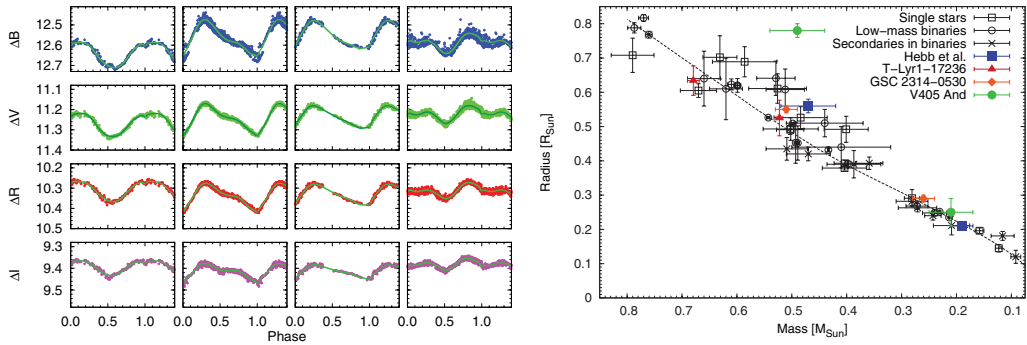
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## 1. Introduction

V405 And is an X-ray emitting active binary detected by the ROSAT satellite (Voges *et al.* 1996). The first detailed study of the system was done by Chevalier & Ilovaisky (1997), who detected an orbital period of  $P_{\text{orb}} = 0.465$  days, and a small, near grazing eclipse. The authors found that the primary and the secondary have spectral types of M0V and M5V, and both of them are active, as both show H $\alpha$  emission. Vida *et al.* (2009) presented photometric  $BV(RI)_C$  data, analysed optical spectroscopic measurements, and found, that the light curve modulation is caused by the combined effect of spottedness and binarity. Using an iterative modelling method to separately describe these two effects, the authors determined the physical properties of this binary system. The primary and the secondary component was found to have masses of  $0.49 M_{\odot}$  and  $0.21 M_{\odot}$  respectively, thus the primary is supposed to consist of a radiative core and a convective envelope, while the secondary is probably fully convective. The radii of the two components are  $0.78 R_{\odot}$  and  $0.24 R_{\odot}$ . Plotting these values on the theoretical mass-radius diagram of Baraffe *et al.* (1998) together with other binaries, we find that the secondary fits well to this relation, but the primary has a significantly larger radius than the theoretically predicted value.

## 2. Observations and analysis

We have obtained new  $BV(RI)_C$  photometry with the 1m RCC telescope at Piszkestető between JDs 2455148 and 2455531 (2009 November–2010 November, about 700 days after the light curves modelled in Vida *et al.* 2009). Previously we found the light curve to be stable (Vida *et al.* 2009), but during the time of the new observations the surface seemed to evolve significantly. The main spotted area moved from phase  $\approx 0.5$



**Figure 1.** Left: Fits to  $BV(RI)_C$  light curves of V405 And. The first column shows the results from Vida *et al.* (2009), the rest show new results. Right: Mass-radius diagram for 5 Gyr stars from Baraffe *et al.* (1998) (with continuous line). Dots show measurements of López-Morales (2007), Blake *et al.* (2008) and López-Morales *et al.* (2006). Filled symbols denote V405 And, GSC 2314-0530 (Dimitrov & Kjurkchieva 2010), T-Lyr-17236 (Devor *et al.* 2008), and 2MASS 04463285+1901432, a binary in NGC 1647 (Hebb *et al.* 2006).

to phase  $\approx 1$  in the first two new seasons, and in the last season two active nests were observed: around phases 0.1 and 0.5.

Using the same modelling method described in Vida *et al.* (2009), we modelled the new observations using PHOEBE (Prša & Zwitter 2005) and SpotModel (Ribárik *et al.* 2003). The light curves and the fits are plotted in Fig. 1. The models fitted to the new observations left the system parameters unchanged. This indicates, that the radius of the primary is indeed much larger than expected. The two known similar binaries with similar structure, GSC 2314-0530 (Dimitrov & Kjurkchieva 2010) and the one from Hebb *et al.* (2006) does not show this behaviour, although the primary of 2MASS 04463285+1901432 (Hebb *et al.* 2006) has somewhat larger radius. This indicates that V405 And is a currently unique system, definitely worthy of further studies.

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