ECLIPSING BINARY SYSTEM V376 AND: OBSERVATIONS AND SOLUTIONS

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Abstract:

We present ground-based photoelectric observations of the newly discovered eclipsing binary system V376 And. The observations were carried out at Bucharest Observatory (Romania) and Rozhen Observatory (Bulgaria). Six times of minima and a new ephemeris are presented. The orbital parameters of the system are determined by modeling the light curves obtained.

Introduction

V376 And is a W UMa type variable star identified as such by the Hipparcos/Tycho mission. It has a period of 0.798669 days and a magnitude oscillating between 7.683 and 8.002 [1]. The system was spectroscopically investigated in [2]. Several times of minima are given by [3] and [4]. Systematic optical observations in B and V filters have been carried out in [5] and [6].

Observations

The observations were performed in Rozhen and Bucharest with a 60/750 cm Cassegrain telescope and a 50/750 cm Cassegrain telescope, respectively, both equipped with single channel photometers. The date, place and phase coverage of observations are listed in Table 1 [6].

Table 1. Phase coverage.

Date	Observatory	Phases	Date	Observatory	Phases
11/16/2000	Rozhen	0.61-0.83	10/13/2003	Bucharest	0.08–0.28
11/17/2000	Rozhen	0.96-0.11	11/08/2003	Bucharest	0.54-0.75
09/22/2003	Bucharest	0.90-0.10	11/13/2003	Bucharest	0.85-0.06

09/23/2003	Bucharest	0.14-0.36	11/21/2003	Bucharest	0.82-0.07
09/28/2003	Bucharest	0.43-0.62	11/22/2003	Bucharest	0.23-0.36
10/10/2003	Bucharest	0.36-0.52	12/17/2003	Bucharest	0.45-0.55

Table 2. Times of minima for V376 And.

Min HJD	Error	Type	Filter	Reference
2448500.7420	0.001	I	Hp	[1]
2451510.5408	0.0014	II	R	[3]
2451510.5419	0.0010	II	V	[3]
2451510.5421	0.0008	II	B	[3]
2451644.3215	0.0028	I	spec	[2]
2451865.53952	0.00018	I	V	[5]
2452595.5273	0.0006	I	BV	[4]
2452905.42037	0.00014	I	V	[5]
2452911.41258	0.00021	II	V	[5]
2452957.33934	0.00041	I	V	[5]
2452965.31396	0.00024	I	V	[5]
2452991.28162	0.00028	II	V	[5]

The light curves show a significant O'Connell effect in both colors (Fig.2 and Fig.3). The B-V values suffer a jump around the secondary maximum in the color index-phase space (Fig.1). Unfortunately, this region was scanned only on November 16, 2000 and partially on November 8, 2003, and even though the measurements were made with different instrumentation, at this moment we can not exclude the possibility of this being an artifact of some errors in the data acquisition process. Our skepticism is also partly motivated by the results of the analysis of the light curves, which will be discussed in the next section. Further observations are planned in the attempt to settle the issue. A compilation of all times of minima available in literature are presented in Table 2. Using the whole set of primary minima a new ephemeris was obtained [6]:

$$\text{Min I} = \text{HJD } 2452905.4178 \pm 0.0030 + 0^{d}.798672 \pm 0.000001\ E$$

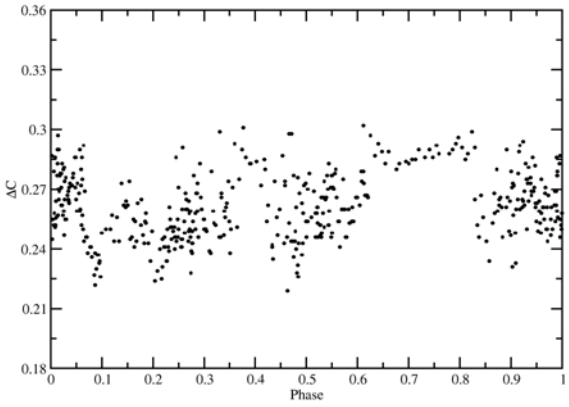

Figure 1. B-V values for V376 And.

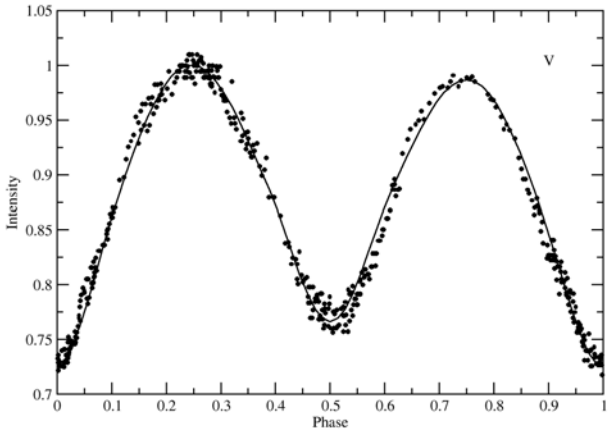

Figure 2. Normalized light curve of V376 And in filter V and the best fit model with parameters from Table 3.

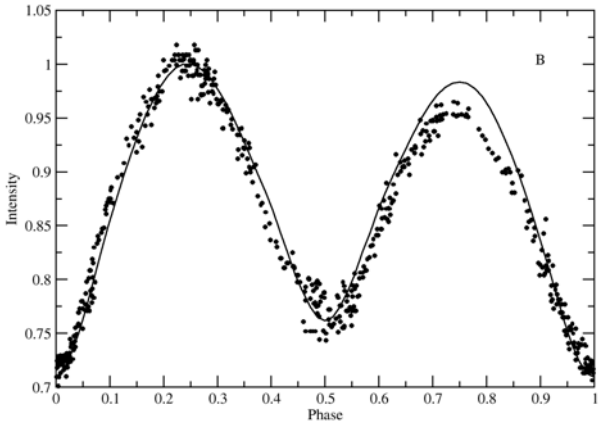

Figure 3. Normalized light curve of V376 And in filter B and the best fit model with parameters from Table 3.

Solutions

The observed intensity difference between the B and V filters can be in principle easiest explain by hypothesizing the presence of spots on the surface of stars. In particular, we took the most mathematically economic case, that is a circular (15° radius) cold spot (1000 K bellow the surface's temperature) in the plane containing the line that connects the centers of the stars (β_{spot} =0°) on the surface of the primary component of the system.

We further assumed that the orbits are circular, the rotation axis of both stars are perpendicular on the orbital plane, the system has the property of synchronism (with the revolution counter-clockwise), the convection processes are dominant (gravity-darkening coefficient g=0.32) and the albedo A has a value of 0.5. In order to obtain the parameters of the system, a custom-made code based on the algorithm of [7] was used. Given the availability of spectroscopic observations [2] we put strong constraints on the mass ratio q=0.30 and the temperature of the primary component T_1=9600 K (using tables from [8]). The Roche lobe fill-out factor f, the orbital inclination with respect to the line of sight i, the temperature of the secondary T_2 and the longitude of the spot λ_{spot} (measured clockwise with respect to the line connecting the centers of

the two stars) were free parameters. Table 3 presents a summary of the best fit parameters for V filter data. The attempt to use the same parameters to overall fit the B filter data fails completely (Fig.2 and Fig.3).

Table 3. Best fit parameters for V filter data.

f	0.44 ± 0.04	T_2	8800 K
i	65°.7 ± 0°.5	λ_{spot}	315°
$\Omega_1=\Omega_2$	3.72	$\Sigma(O-C)^2$	0.00014

Discussion

Using the best fit parameters from V filter data to account for the observations in the B filter reveals reasonable compatibility in the phase range of the primary maximum, but is inconsistent with the rest half of the light curve. The reasons for this discrepancy can be divided in two categories: either, as previously mentioned, the data for the secondary maximum were somehow contaminated by yet unknown instrumental errors, or some of the assumptions employed (notably the ones related to the presence of the spot) are not correct. Further observations of this system are required.

References

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