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The first photometric study of W UMa eclipsing binary OQ Dra

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HIGHLIGHTS

- A ccd photometry study of W UMa contact binary OQ Dra is presented.
- Data reduction and aperture photometry were done in IRAF.
- Parameters of the system achieved by light curve modelling with PHOEBE (W-D code).
- Unspotted and spotted models has been introduce.
- Period=0.33967, Mass ratio=0.55, i=73 and spectral type of K achieved for OQ Dra.

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ABSTRACT

The present study is an analysis of V-band CCD observations of new W UMa contact binary OQ Dra. To carry out the analysis, Primary and secondary minimum were obtained and new epoch was calculated. The computed period of system was 0.33967 day. Light curve analysis was performed using Binary Maker 3 and PHOEBE that uses the latest Wilson–Devinney code. We obtained photometric mass ratio of $q_{ptm} = 0.55$.

O'Connell effect also was seen in the fitted model. Finally, the best model was achieved by introducing 2 spots on each component.

1. Introduction

W UMa systems are eclipsing binaries with short periods about 0.25 to 1 day (Acerbi et al., 2011). They can be easily recognized by their light curve shape. The depth of primary and secondary minima in these systems are approximately equal, and magnitude variability range is about 0.1 to 1 (Rucinski, 2000).

Binnendijk (1978) classified W UMa EBs into two sub-classes, a-type and w-type according to their spectral type. A-type systems are from A to F spectral type and have deeper primary minima due to transiting larger and hotter component, while w-type systems are of late spectral type from G to K showing primary minimum due to occultation of smaller and less massive component.

The orbital period of a-type systems is generally less than 0.3 day and in w-type stars lays between 0.3 day to less than a day. In w-type systems, both of the components fill or over-fill their critical roche lobes and are enclosed in a common convective envelope (Joshi et al., 2015).

Most of W UMa binary light curves show O'Connell effect (McCartney, 1997), that is a difference between the brightness at the maximums (the brightness at 0.25 phase is different from that at 0.75 phase) (O'Connell, 1951).

W UMa type system's period has also some slight change that might be because of mass transfer between the stars of the system (Li et al., 2005).

OQ Dra is also a W UMa type binary that was uncovered by Khruslov (2007).

2. Observations and data reduction

The photometric observations were performed over 5 nights between 21 June 2015 and 14 July 2015 at RIAAM observatory (research institute for astronomy and astrophysics of maragha). We used a 12 in. MeadeLX200 schmidt-cassegrian telescope and a computerized equatorial mount that was controlled with TheSky6 software. Our 16bit monochrome ccd had quantum efficiency of 65% and readout noise of about 7–10. The ccd's array was 752 × 582 pixels (unbinded) with 6.25 μm pixel size. Also a 0.63x focal reducer were used, that provided 12 × 9 arcmin field of view (Fig. 1).

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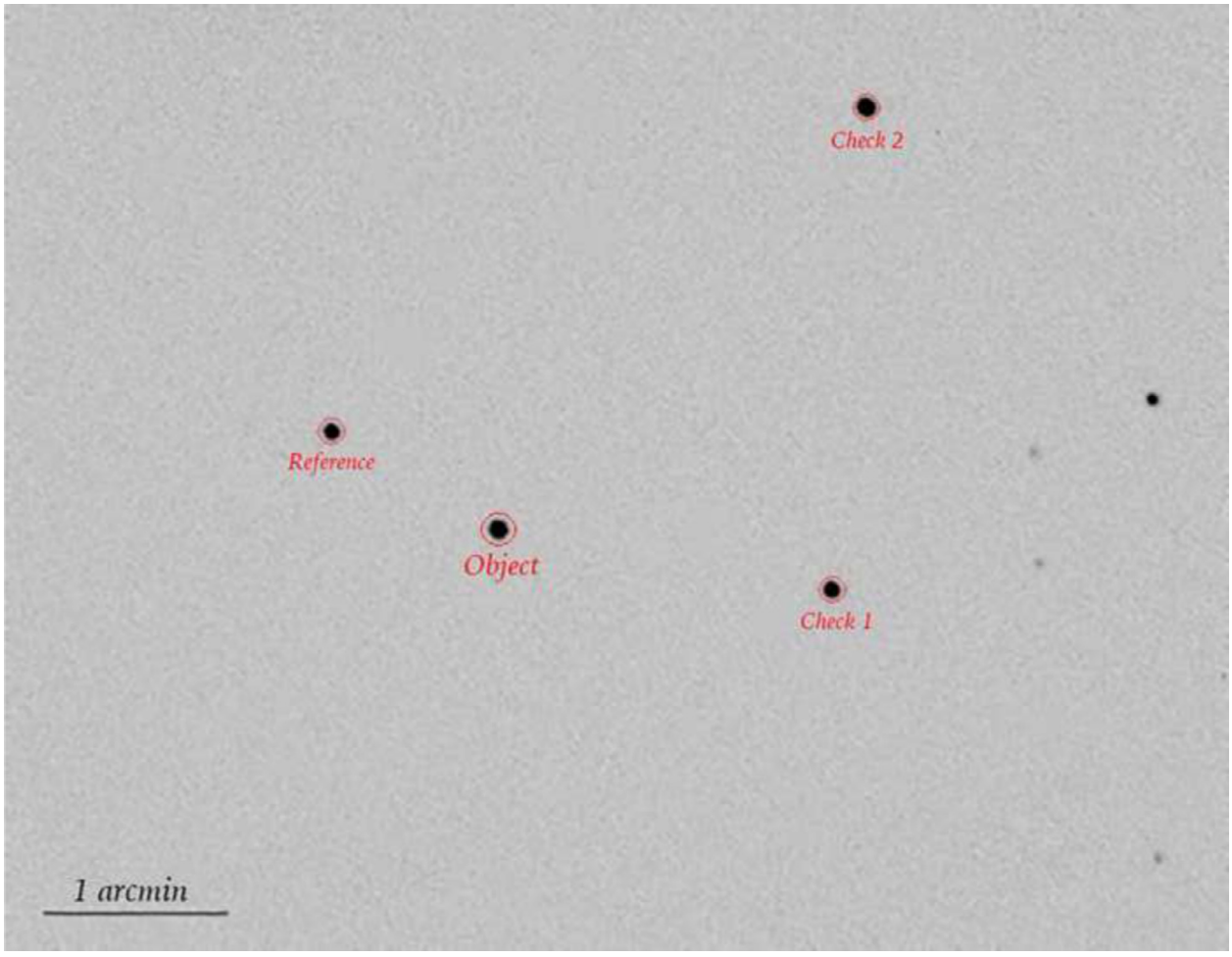

Fig. 1. OQ Dra, reference and check stars in telescope's field of view.

Table 1
Object, check and reference star.

	Star	RA	Dec	Mag
Obj	OQ Dra	11 49 25.9	+72 34 01.4	12.46
Ref	GSC 0439900951	11 49 11.5	+72 33 25.4	13.88
Chk1	GSC 0439900541	11 49 54.8	+72 34 23.0	13.77
Chk2	GSC 0439900737	11 49 57.2	+72 31 23.2	13.01

Table 2
Minimums.

Minimum type	HJD	Root mean square error
Primary	2457195.3766	0.00039
Primary	2457196.3944	0.00030
Secondary	2457217.2848	0.00042
Secondary	2457218.3051	0.00041

The ccd was controlled by MaximDL v5, and considering 80% of ccd cooling fan's power, the temperature was fixed at −15 °C.

With 30 s exposure time, we achieved signal-to-noise ratio of about snr = 90. 1670 frames were taken in v-band filter (Just Johnson v-band filter were available during observation season). 40 dark and bias frames were taken each night during the observing time, and 20 twilight flat frames (by pointing telescope to west horizon just before the sunrise) were also taken, and were combined using median method. We used IRAF for data reduction procedure. Master bias and master dark frames, and master flat were obtained, and calibration was performed on light frames. We used aperture photometry method, and data were exported as ascii file with columns of JD time, check stars magnitude, and object star magnitude.

Object, check and reference stars are presented in Table 1.

3. Period analysis and O-C diagram

3.1. Minimums and period

After data reduction was done, Object and check stars magnitude values were imported to a spreadsheet and light curve was obtained. JD to HJD correction was used also in time series.

The orbital period of OQ Dra was determined by the obtained primary and secondary minima as seen in Table 2:

Period = 0.33967 ± 0.00015 day.

Phases are calculated by using the equation:

$$Phase = decimal[(HJD - epoch)/period] \quad (1)$$

3.2. O-C diagram

With collected minima from IBVS-6029 and IBVS-6070, the period changes were analyzed. The O–C values were calculated using