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Photometric study of the short period W UMa system – FZ Orionis

J. Rukmini, P. Vivekananda Rao* and B.D. Ausekar

Centre of Advanced Study in Astronomy, Osmania University, Hyderabad 500007, India

Abstract. Photoelectric B, V observations of the eclipsing binary system FZ Orionis obtained from the Japal-Rangapur Observatory during the years 1981 to 1992 are presented and studied. No period changes in the system are detected. The light curves are analysed using the Wilson-Devinney method and the system parameters are derived.

1. Introduction

Hoffmeister discovered the variability of the eclipsing binary, FZ Orionis (FZ Ori). The system has been later classified as a W UMa type binary by Figer (1983) and La Brogue (1984) from its light curve. They derived a period of 0.3999860 day. The system has been observed photometrically through U, B, V filters during 1984-86 by EI- Bassuny (1993), whose light curve resembled typical of a W UMa type. Depths of both minima are found to be comparable. Visual light curves obtained by La Brogue et al. and Bassuny also showed slight difference in the brightness at two maxima i.e., the secondary maxima is brighter than the primary. Mean value of the period obtained for the system has been found to be 0.3999873 day agreeing with that of Eggen (1967) relation. No change in the system colour was found except for slight reddening at minima. The ephemeris obtained was

$$\text{Min I} = \underset{5}{2444024.4645} \pm \underset{10}{0.399984}E$$

The variability in the light curve of FZ Ori is attributed to the presence of the third body and mass loss from the system.

Bassuny's work gave the spectral type of the system as F5, while Kholopov (1985) listed it as G0 type. Applying Fourier series and following Ruscinski's (1973) method, Bassuny categorized FZ Ori as W–subtype contact binary with the following parameters. Angle of inclination (i) = 75° to 90°, mass ratio (q) = 0.2 to 0.6, the secondary minimum is attributed to the eclipse of massive component confirming W–subtype contact binary, the fillout

*e-mail : pvr@ouastr.ernet.in

parameter (f) = 0.5 to 1.0, indicating that the system has a shallow common envelope less than or about 50% of the space between inner and outer critical potential surfaces. In order to determine reliable elements for the system and also to understand the nature of this binary, it is included on the observing program at Japal - Rangapur observatory, Hyderabad.

2. Observations

The binary system FZ Orionis (HD 288166) was observed photoelectrically through B and V passband filters matching that of the standard systems (Johnson and Morgan, 1953) during 1981-92. Observations were made with a thermoelectrically cooled EMI 9658B photomultiplier attached to the 1.2m reflector of the Japal – Rangapur observatory. The nearby star HD 37804 was used as a comparison star and HD 37885 as the check star. The output from the photomultiplier is fed to a fast pre-amplifier that amplifies the pulses, then through a discriminator it is fed to the photon counter. The photon counts are recorded into the computer through a buffer interface by means of a suitable data acquisition program. The method of data reduction and the photometric data can be obtained from "Contributions from Nizamiah and Japal – Rangapur Observatory, Osmania University, Hyderabad", which will be published shortly.

3. Analysis

The primary minima of the system was observed on several occasions. Using the epochs of these minima along with those available from the literature, we have obtained the following improved ephemeries :

$$\text{Min I} = 2446802.3502 \pm 0.399984080E$$
$$\qquad\qquad 5 \qquad\qquad 10$$

The light curves are plotted for both the passbands using the above ephemeris. A visual observation of the light curve indicate that FZ Ori is that of the W UMa type. A large scatter is found in the light curves for both the passbands.

Analysis on the system is performed using the Wilson – Devinney program (Wilson & Devinney 1971) as it gives reliable elements. Because of the contact configuration of the system, mode 3 is used for the analysis. In executing the W – D program the following parameters are fixed. The temperature of the primary T_h = 6030 K (Allen, 1976; Popper, 1980; Schmidt-Kaler, 1982) corresponding to the spectral type of GO (Kholopov 1985); gravity-darkening coefficient G_h, G_c = 0.32 for both the components, since FZ Ori is considered to be a contact system (as evident from its light curve) with a convective envelope; eccentricity e = 0, considering a circular orbit; the bolometric albedos A_h, A_c = 0.5, for convective envelopes; the limb-darkening coefficients x_h, x_c = 0.6 (Al-Naimiy, 1978); and since no spectroscopic data is available for fixing the value of mass-ratio 'q', the computation of elements are performed for the various values of mass - ratio, considering the range given by El-Bassuny, the values chosen are q = 0.2 to 0.9 in steps of 0.1 and from 0.9 to 1.0 in steps of 0.02; corresponding values of surface potentials are computed following the equation given by Kopal (1959).

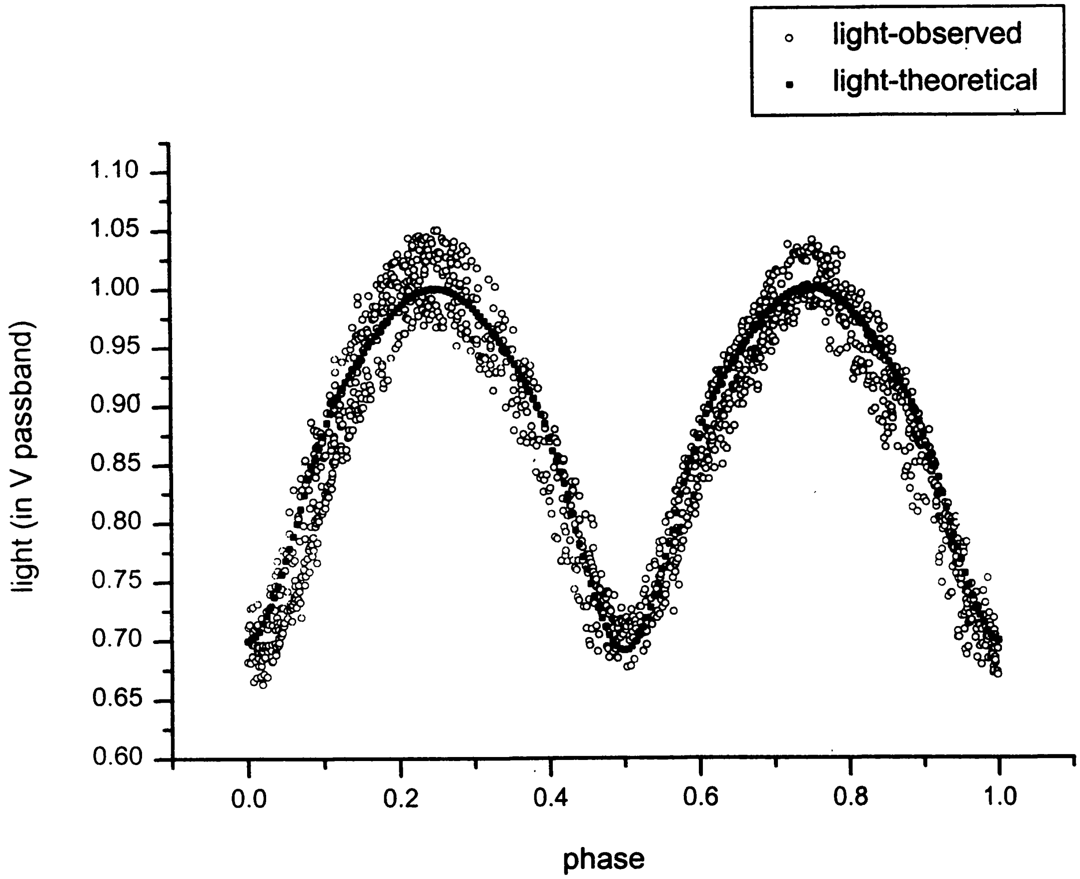

Figure 1. FZ Ori : Light curve in the V passband. Open circles (o) represent observations and solid squares (■) represent theoretical values obtained from Wilson-Devinney solution.

Computations are carried out using the DC program of the W - D method by varying the parameters viz. i, L_h, T_c alternatively till the sum of the residuals, $\Sigma W(O\text{-}C)^2$ showed a minimum and the corrections to the parameters became smaller than their probable errors. In order to check the internal consistency of the results separate solutions for each of the B and V light curves are made. The results of analysis for individual B and V light curves given in cols. 2 & 3, table 1 indicated that the individual solutions are consistent and that a combined solution for B and V is adequate to derive the system parameters. A plot of the $\Sigma W(O\text{-}C)^2$ versus q indicate that a minimum occurred at q = 0.92 for both the passbands.

Taking the average parameters of these solutions given in col. 2 and 3, table 1 as preliminary elements a final combined solution is obtained keeping i, L_h and T_c as adjustable parameters and the other parameters as fixed. The results of the combined solution is given in col. 4, table 1. The theoretical curve for the V passband obtained from the elements given in col. 4, table 1 is shown in figure 1 as solid squares. In this figure open circles represent individual observations. The fit of the final elements to the observations is found to be satisfactory.

Table 1. FZ Ori : Elements obtained from the solution of individual and combined VB light curves using W-D method, keeping $T_{e,h}$ = 6030 K and q = 0.92 as fixed parameters.

Element		V	B	Combined VB solution
1		2	3	4
*$T_{c,h}$ K		6030	6030	6030
$T_{e,c}$ K		5911	6163	6108 ± 37
*q		0.92	0.92	0.92
i°		68.63	69.13	68.81 ± 0.04
r_h	pole	0.3929	0.3929	0.3929 ± 0.0013
	point	0.5000	0.5000	0.5000 ± 0.0014
	side	0.3816	0.3816	0.3816 ± 0.0014
	back	0.4122	0.4122	0.4122 ± 0.0015
r_c	pole	0.3490	0.3490	0.3490 ± 0.0020
	point	0.4828	0.4828	0.4828 ± 0.0020
	side	0.3662	0.3662	0.3662 ± 0.0019
	back	0.3973	0.3973	0.3973 ± 0.0020
L_h		0.5406	0.5457	V 0.5299 ± 0.0007
				B 0.5570 ± 0.0008
L_c		0.4594	0.4543	V 0.4701
				B 0.4430
$+l_3$		0.0	0.0	V 0.0
				B 0.0
x_h		0.60	0.60	V 0.60
				B 0.60
x_c		0.60	0.60	V 0.60
				B. 0.60
*A_h		0.5	0.5	0.5
*A_c		0.5	0.5	0.5
*G_h		0.32	0.32	0.32
*G_c		0:32	0.32	0.32

* Fixed parameters
\+ In units of total system light at phase 0.25

Conclusion

Most of the light curves of W type contact systems show asymmetries in the light curves which are attributed to spots on one or both the components. Our light curves do not show any asymmetry unlike the observations of El Bassuny. This could be explained that the system may be in its quiescent phase during the period of our observations. Our observations show a large scatter for which we could not give a proper explanation. Our derived elements are not in agreement with those derived by Bassuny. However they are in agreement with most of the W UMa type systems. The derived elements indicate that the system is in the second stage of mass transfer because of the higher temperature of the secondary and its luminosity.

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