The Light-Time Effect in the W UMa – type eclipsing binary FZ Ori

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Abstract

New times of minima of FZ Ori, obtained at the Athens University Observatory, have been used together with all reliable timings found in the literature in order to study the period variation and search for the presence of a third body in the system. Its O – C diagram is presented and apparent period changes are discussed with respect to the light-time effect (LITE). New improved LITE elements, orbital period and minimum mass of potential third body are given.

1. Introduction

Hoffmeister (1934) discovered variability in the light of FZ Orionis (HD 2888166, GSC 119 01014, $\alpha_{2000} = 05^h\ 41^m\ 21^s$, $\delta_{2000} = +02^0\ 36'\ 23''$). Kippenhahn (1953) classified the system to be of *β Lyrae* type, and estimated the period to be 1.597 days. Figer (1983) and Le Brongue *et al.* (1984) suggested the system was instead of the W UMa-type and reported a period of 0.399986 days. El-Bassuny (1993) and Rukmini *et al.* (2001) suggested that the variability in the light curve could be due to the presence of a third body and/or mass loss from the system. Qian and Ma (2001) made a period study and determined a decreasing period rate. Byboth, Markworth and Bruton (2004) obtained photometric observations and determined the photometric elements of the binary.

2. Observations

The system was observed with the 40 cm Cassegrain telescope of the University of Athens Observatory, Greece, with a ST8XMEI CCD camera using the Bessell R filter. Observations were carried out during one night in December 2006 and two nights in January 2007. Differential magnitudes were obtained by using as comparison star the GSC 119:361, whose magnitude variation was checked with the star GSC 119:263. Two secondary and one primary times of minima were obtained and they are given in Table 1.

Table 1. The times of minima from our observations

HJD (2400000+)	*Error*	*Type*
54099.45835	0.00019	II
54102.45888	0.00006	I
54109.45926	0.00008	II

3. O – C diagram analysis

The O – C residuals of all compiled times of minima have been computed, initially, according to the linear ephemeris *T = 2444024.4629 + 0.39998443*E (Kreiner et al. 2001*). Reliable times of minima since 1932 have been used in the present study (18 times minima with photographic methods, 3 with photoelectric methods, 30 visual and 35 with CCD). Our O – C diagram has been analyzed with a least squares method and the results are presented in the figures 1-4. In Fig.1 we present the O – C diagram fitted only with a parabolic curve, which suggests a mass transfer in the binary, while in Fig. 2 the fit was made by a sinusoidal curve, which suggests a possible third body. Finally in Fig. 3 we present the fitting with parabolic and sinusoidal curves, and in Fig. 4 the residuals obtained by subtracting LITE solutions. The new light elements of the binary and the orbital parameters of the possible 3rd body are given in Table 2.

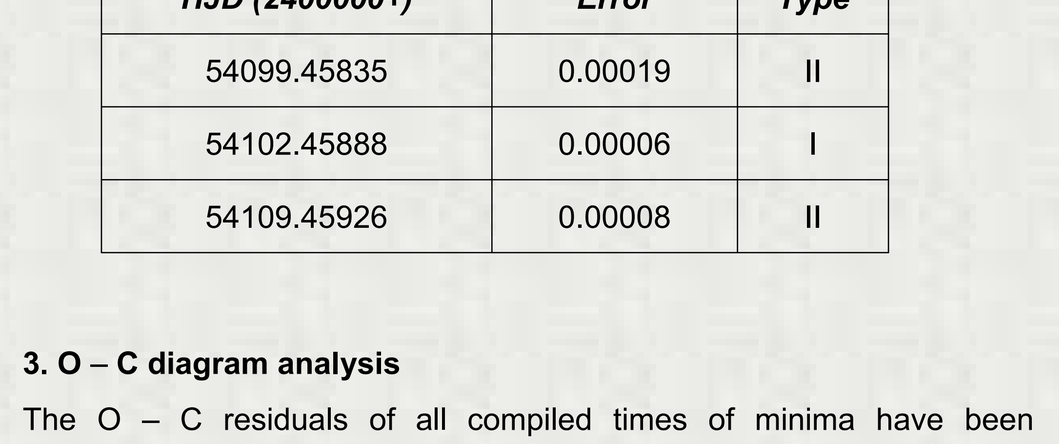

Fig. 1 & 2. The O – C diagram of FZ Ori fitted by a parabolic (left) and a sinusoidal curve (right).

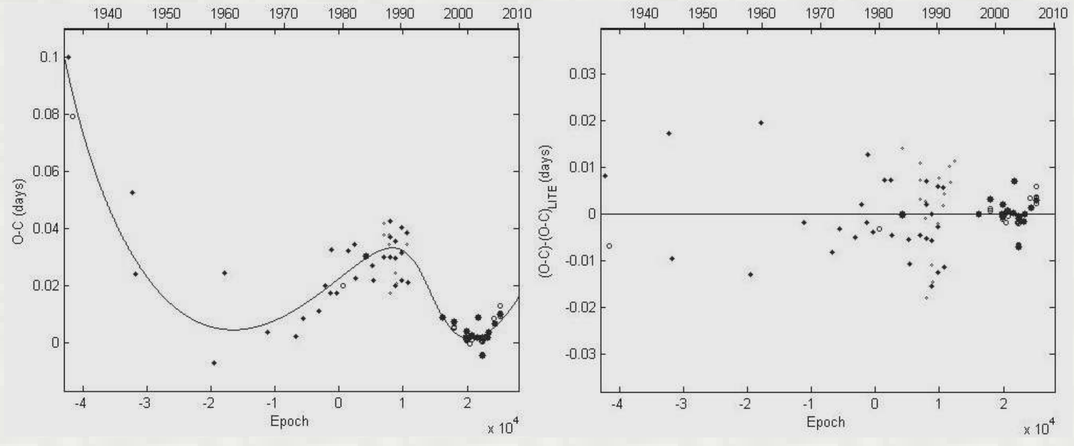

Fig. 3 & 4. The O – C diagram of FZ Ori fitted by a parabola and a sinusoidal curve (left), and the residuals obtained by subtracting LITE solution (right).

Table 2. The LITE parameters of FZ Ori

Spectral type	G0V
$M_1 + M_2$ ($M_\odot$)	2.1
Mass transfer ($M_\odot$ / yr)	2.8 (1) x 10^{-7}
P_3 (yrs)	49 (2)
A (days)	0.021 (1)
e	0.6 (2)
ω (deg)	189 (9)
$f(m_3)$ ($M_\odot$)	0.036 (4)
$M_{3,min}$ ($M_\odot$) (i = 90º)	0.65 (2)

4. Discussion and Conclusions

New LITE parameters for the eclipsing binary FZ Ori have been derived by means of an O – C analysis. A third body in an eccentric orbit with a period of 49 years and a minimum mass of 0.65 $M_\odot$ has been found. However, for a more accurate determination of the third body's elements, more timings of minima and/or an appropriate confirmation of its existence by other methods (e.g. radial velocity measurements) are needed. Assigning a weight of 1 to visual data, 5 to photographic data, and 10 to photoelectric and CCD observations, we found the following quadratic ephemeris *T = 2450479.403 (5) + 0.3999858 (3)*E + 0.31 (2) x 10^{-10}*E^2* and a period increase rate of dP/dt = 5.6 (4) x 10^{-8} days/yr.

5. Acknowledgements

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6. References

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