LIGHT-TIME EFFECT IN ECLIPSING BINARIES

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Abstract

The role of the light-time effect in stellar studies is briefly discussed. Based on the list of published photoelectric minima, the new parameters of the third body's orbit for the two well-known eclipsing binaries, TW Dra and TX Her, are derived. For each system the minimum mass of a third component is computed.

1. Introduction

If a periodic variable star is a member of a binary system, the variable's motion about the binary orbit will produce a Doppler effect, and the observed period of variation will increase and decrease. This can also be thought of as the effect of the time required for the variable's light to cross the binary orbit, and for this reason it is often called the light-time effect (hereafter LITE). Its effect on the apparent periods of eclipsing binaries has been discussed by many authors (see a very comprehensive study by Mayer 1990). The LITE, apsidal motion, and the transfer of mass between components are three main known reasons of a variety of period changes in eclipsing binaries.

However, eclipsing binaries are not the only domain of the LITE. This phenomenon was also detected in other groups of variable stars, such as Cepheids, δ Scuti, and RR Lyrae stars (see paper by Szatmáry 1990). For example, a precise solution of the LITE orbit for the TU UMa (RR Lyrae type) based on the maxima analysis may be found in Saha and White (1990).

The LITE can help us very effectively solve the question of stellar duplicity, triplicity, and multiplicity in many cases. Therefore it is a welcome source of information.

Based on the list of photoelectric minima available in the literature, we derived as an example of our program the new parameters of the third body's orbit for the two well-known eclipsing binaries discussed below.

2. TW Draconis

The LITE caused by the presence of additional components in this semi-detached binary (A5+K0) was discussed by Abhyankar and Panchatsaram (1984). Two new times of minima obtained by Agerer and Diethelm (1985) fit the sinusoidal curve quite well, so a triple system is adequate for the description of the O-C variations. Based on 49 times of photoelectric minima we obtain the linear ephemeris by means of the least squares method:

$$\text{Min I (JD}_{\text{hel.}}) = 2432341.8862 + 2.80685822\ (E - 3075). \qquad (1)$$

The newly derived LITE parameters are:

$P = 8854$ days = 24.24 years, i.e., 3150 P_0

T_0 (periastron) = JD 2436362

$e = 0.168$

$\omega = 2^o$

Semi-amplitude = 0.0154 day

The mass function has the value $f(m_3) = 0.03368\ M_\odot$, from which the minimum mass of the third body follows as $0.74\ M_\odot$ (under the assumptions: $m_1 = 1.90\ M_\odot$, $m_2 = 0.82\ M_\odot$).

All of these derived parameters are in good agreement with the alternate scenario in Abhyankar and Panchatsaram (1984). Figure 1 shows the O-C diagram with this LITE curve.

3. TX Herculis

The LITE in this Algol-type variable (A7+F0) was detected by Vetešník and Papoušek (1973). The following new ephemeris results from the collection of 67 photoelectric times of minima available in the literature:

$$\text{Min I (JD}_{\text{hel.}}) = 2430325.204 + 2.059809737\ E. \qquad (2)$$

The corresponding parameters for the LITE orbit are:

$P = 18970$ days = 51.9 years, i.e., 9210 P_0

T_0 (periastron) = JD 2444775

$e = 0.767$

$\omega = 45^o$

Semi-amplitude = 0.0127 day

These values were obtained with the new ephemeris using the least squares method. The mass function has the value $f(m_3) = 0.00666\ M_\odot$, from which the minimum mass of the third body follows as $0.44\ M_\odot$, (under the assumptions: $m_1 = 1.62\ M_\odot$ and $m_2 = 1.45\ M_\odot$, Popper 1980). Figure 2 shows the O-C diagram with this LITE curve.

References

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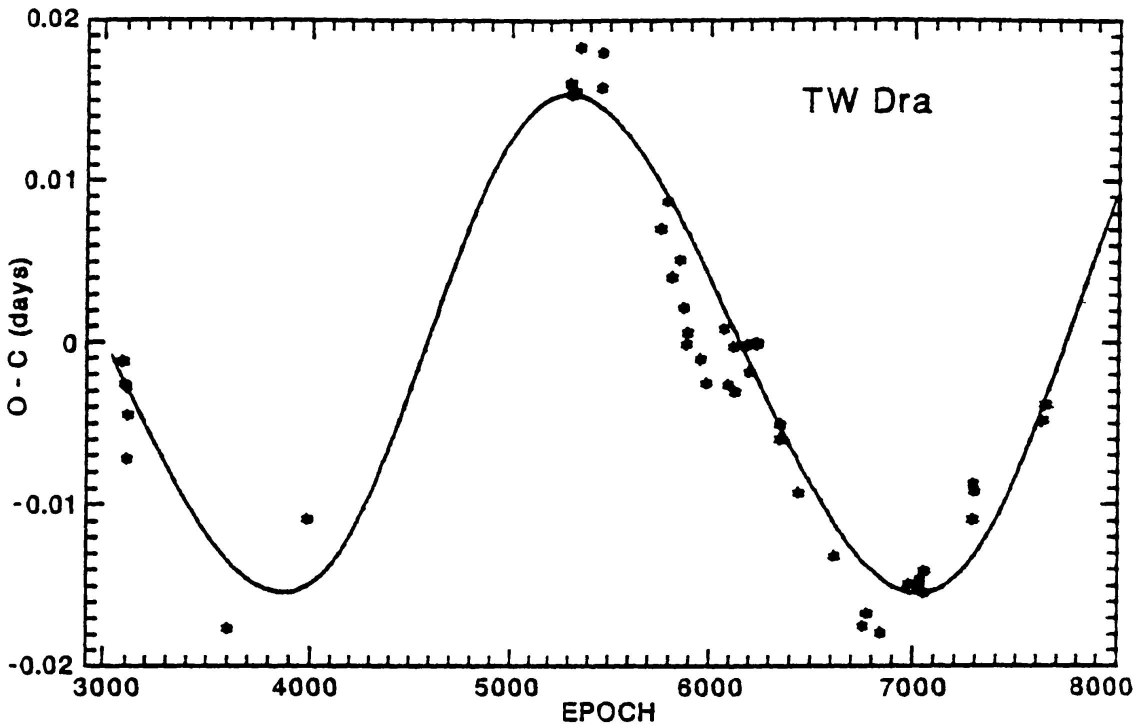

Figure 1. O-C diagram of TW Dra according to equation (1).

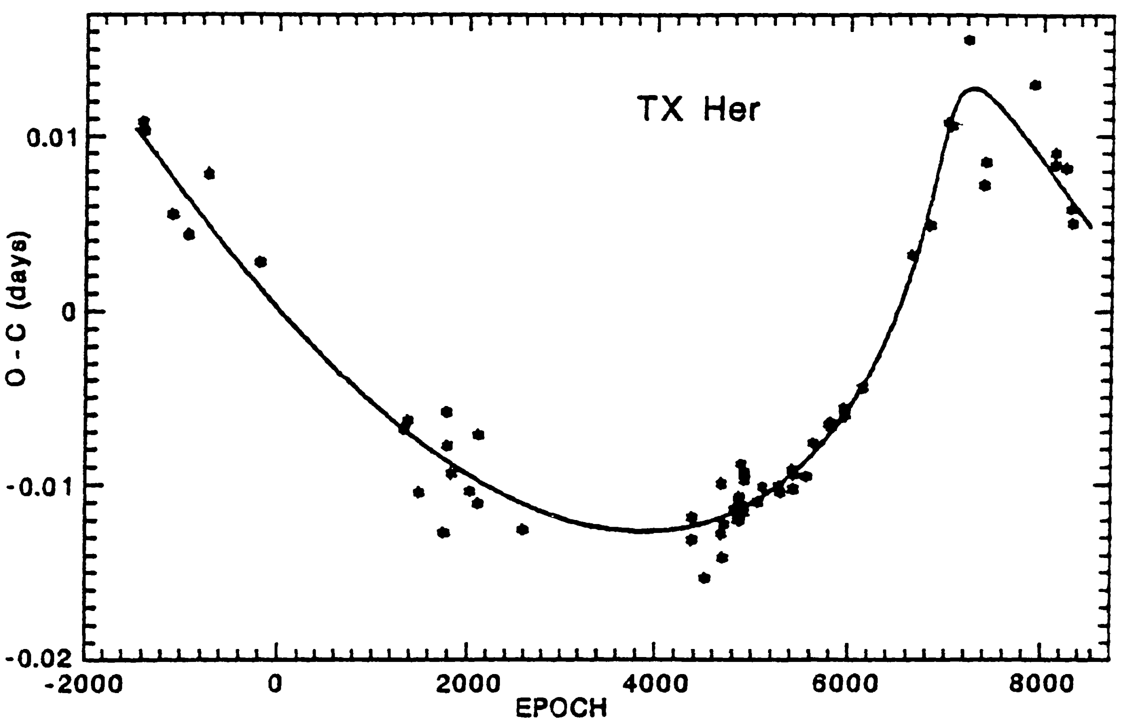

Figure 2. O-C diagram of TX Her according to equation (2).