

Up-to-date linear elements of eclipsing binaries

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Abstract

About 1800 O-C diagrams of eclipsing binaries were considered and up-to date linear elements were computed.

Key words: Stars: eclipsing binaries: ephemerides

The first regular ephemerides for 31 eclipsing binaries were published by Banachiewicz (1923) in *Rocznik Astronomiczny Obserwatorium Krakowskiego - Supplemento Internationale*, known as SAC (Supplemento ad Annuario Cracoviense). Dr. K. Kordylewski and other astronomers from the Astronomical Observatory of the Jagiellonian University continued this work until 2003, when the last printed edition of SAC (No 74) was published. It contained elements for 881 binaries.

Predictions of the mid-eclipse times are very useful in planning both photometric and spectroscopic observations on eclipsing binaries. The precise time of minimum allows a star to be observed very efficiently using only the important parts of light curves (e.g. either near primary minima or near the phase 0.25, when radial velocity curves are considered). Furthermore, the current value of the period is very significant during the reduction of photometric and spectroscopic observations. As such, updated ephemerides of eclipsing binaries will be used by both professional and amateur astronomers.

The main goal of the present paper was to prepare up-to-date elements of eclipsing binaries as a basis of the ephemerides and to give the current values of the periods. This was possible after investigating period changes of eclipsing binaries and anticipating the period behaviour in the near future. Period changes were studied by inspecting in detail O-C diagrams constructed from the minima taken from literature. The extensive number of minima is contained in the database of eclipsing binaries maintained at Mt. Suhora Astronomical Observatory of Cracow Pedagogical University. As of February 2004, the database contains more than 149,000 timings for about 4,400 eclipsing binaries. The database was used to compile “*An Atlas of O-C Diagrams of Eclipsing Binary Stars*” for 1,140 selected binaries, published by Kreiner, Kim & Nha (2001). Detailed information on the “*Atlas*” can be found on the Internet at:

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<http://www.as.ap.krakow.pl/o-c/>. Recently, Kim, Kreiner and Nha (2003) published some statistics concerning minima from the database and the stars from the “*Atlas*”.

In this paper, about 1800 O-C diagrams were considered. Most of them were published in the “*Atlas*”. The following criteria were fulfilled:

1. At least 10 minima were observed.
2. The minima spanned at least 10 years.
3. Stars that had no minima observations after 1960 were not taken into account.
4. Elements for some interesting objects (e.g. systems showing apsidal motion) were also computed, despite of the fact that the not all criteria were satisfied.

Only the most recent part of each O-C diagram was considered in order to compute the elements. The following factors were taken into account: the weights of the minima (if possible, only photoelectric and ccd minima were used); the shape of the O-C diagram (if a star demonstrates evident period changes only a small part of the O-C diagram was considered); and the total number of points on the O-C diagram.

The best fit of the straight line (representing the linear elements) was obtained using a standard least squares method. The errors of M_o and P were presented when the number of star minima used in computations exceeded seven. The sample of computation results is presented in Table 1. It contains the results for the first 20 eclipsing binaries in the constellation order. The entire table for more than 1,800 eclipsing binaries is available only in electronic form at the Internet address: <http://www.as.ap.krakow.pl/ephem/>.

Table 1

Linear elements of eclipsing binaries

The successive columns of Table 1 contain:

1. The name of a star in constellation order.
2. Information about minima considered in the calculation of the linear elements:

all - primary and secondary minima were used,
pri - only primary minima were used,
sec - only secondary minima were used.

1. The time of the “artificial” minimum M_o (this is not an observational time of minimum!) used for the best fitting of straight line to the O-C diagram. The value of M_o was arbitrarily set close to JD 2,452,500.
2. Mean errors of M_o (shown in round brackets).
3. The current period P of the star obtained during the fitting the straight line to the O-C diagram.

4. Mean errors of P (presented in round brackets). If the number of minima used to determine the elements was smaller than 8, mean errors were not calculated and an asterisk (*) appears inside the brackets.

5. The number of minima used in the computation:

all - the number of all minima,

pri - the number of primary minima,

sec the number of secondary minima.

The number of minima according to the method of observations:

e photoelectric minima

ccd ccd minima

v visual minima

pg minima obtained from a series of photographic observations

p the time of mid-exposure of a photographic plate, taken when the star was *near* minimum. Timing isn't usually very accurate with this method.

1. Years of the first and the last minimum used in the computation. (Many of the stars have a large gap with no minima observed between the first and last year of observations).

2. Date when the computation was finished.

The predicted time of minimum (M_{calc}) can be obtained using the well-known formula:

$$M_{calc} = M_o + P \cdot E,$$

where E denotes the number of epochs.

The number of diagrams and the number of stars with new elements will increase in the future, when new minima of eclipsing binaries became available.

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