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DY HERCULIS: MEMBER OF A BINARY SYSTEM?

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The most recent evolutionary model calculations of δ Scuti stars predict that their periods should be constant or increasing in the majority of cases (Breger & Pamyatnykh 1998). The observed period changes of the stars, however, showed discrepancies and could not be fully reconciled with the theoretical expectations.

One of the high amplitude δ Scuti stars with decreasing period is DY Herculis. The study of its period changes has a long history and led to controversial results. Fitch (1957) assumed a uniform increase in its period:

$$\frac{1}{P}\frac{dP}{dt} = +36.4 \times 10^{-8}\ \mathrm{y}^{-1},$$

while Broglia (1961) and Hardie & Lott (1961) gave the values $+17.5 \times 10^{-8}\ \mathrm{y}^{-1}$ and $19.5 \times 10^{-8}\ \mathrm{y}^{-1}$, respectively, although Hardie & Lott noted that between 1950 and 1959 the period was essentially constant.

Szeidl & Mahdy (1981) used almost 30 years of observations in their study and concluded that the period of DY Her was decreasing:

$$\frac{1}{P}\frac{dP}{dt} = -6.2 \times 10^{-8}\ \mathrm{y}^{-1}.$$

They left the old photographic maximum observed at Konkoly Observatory out of attention, which might already suggest that the period of the star did not change linearly. Yang et al. (1993) carried out a least-squares solution almost to the same data that Szeidl & Mahdy used – the time base of the observations was extended only by 10% with three new epochs – they obtained an essentially slower decrease in the period:

$$\frac{1}{P}\frac{dP}{dt} = -3.5 \times 10^{-8}\ \mathrm{y}^{-1}.$$

The results mentioned above clearly showed that the interpretation of the period change of DY Her was erroneous and therefore we decided to carry out a new period analysis of the star.

The list of photographic and photoelectric maxima published in Szeidl & Mahdy (1981) (see detailed references therein) has been supplemented by the recent observations of Yang et al. (1993), Agerer & Huebscher (1996, 1998) and Agerer et al. (1999), and a new, very accurate normal maximum could be deduced from the Hipparcos photometry:

J.D. max. 2448302.6073.

The old visual observations (Tsesevich 1949, Soloviev 1952) proved to be too uncertain, therefore they were neglected in the discussion.

The $O-C$ values have been computed by the elements (see Szeidl & Mahdy 1981):

$$C = \text{J.D. } 2433439.4865 + 0\overset{\text{d}}{.}148631201 \times E.$$

The yearly means of the $O-C$ values are presented in Fig. 1. These data (together with the normal maximum from the Hipparcos photometry) were taken into account in the least-squares solution with higher weight ($w = 5$).

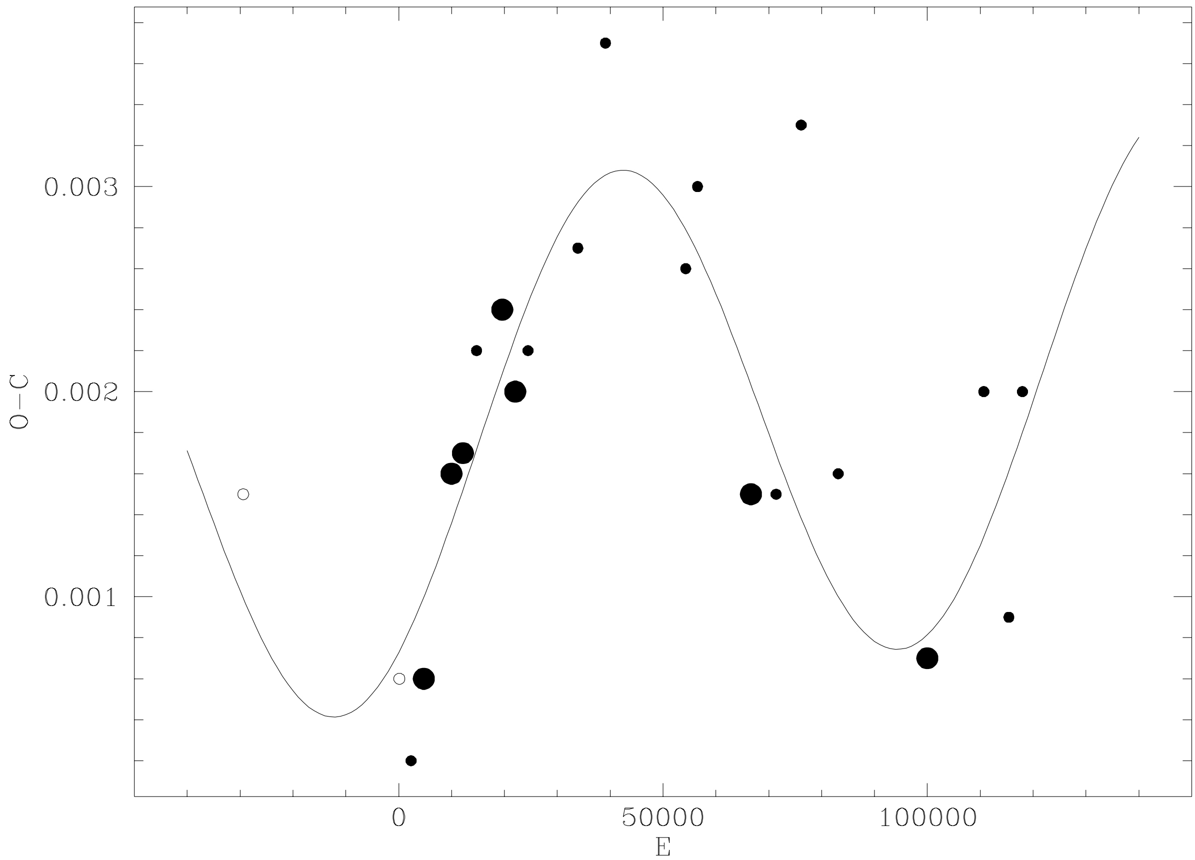

Figure 1. The yearly means of the $O-C$ values. The empty circles indicate photographic, the filled circles photoelectric observations. The big filled circles represent those yearly means, which were derived from three or more individual observed maxima.

It is obvious that the $O-C$ diagram could rather be fitted by a sinusoidal than by a quadratic form. The least-squares solution gives the following fit to the $O-C$ diagram:

$$\begin{array}{l} O-C = 0.00170 + 0.0000000031 \times E + 0.00125 \times \sin(0.0000594 \times E - 0.891). \\ \qquad\quad \pm 0.00032 \pm 0.0000000021 \qquad \pm 0.00038 \qquad \pm 0.0000106 \qquad \pm 0.143 \end{array}$$

The only epoch which deviates from the fit by more than one minute is the observed maximum by Yang et al. (1993) at J.D. 2444755.2290 ($E = 76133$).

The new ephemeris for the times of light maximum is

$$C = \text{J.D. } 2433439.48820 + 0.1486312041 \times E + 0.00125 \times \sin(0.0000594 \times E - 0.891).$$

Because a long sinusoidal wave dominates the $O-C$ diagram, nothing can be said about the evolutionary changes of the pulsation period of DY Her.

Our results suggest that DY Her may be a member of a binary system. If we take this interpretation for granted we obtain the following elements for the system (assuming that the orbit is circular):

$$P_{\rm orb} = 15720 \pm 2620 \text{ days} = 43.04 \pm 7.17 \text{ years},$$

$$a_{\rm DY} \sin i = 0.22 \pm 0.07 \text{ AU}.$$

The binary nature of the system cannot easily be demonstrated by radial velocity measurements, because the amplitude of the radial velocity curve is around $K_{\rm DY} = 0.15$ km s^{-1}.

The other component of the system has no significant photometric effect and is probable a dwarf star of low mass.

Although the most plausible interpretation of sinusoidal $O-C$ diagram is the light-time effect caused by the orbital motion, we have to admit that other suggestions are mentioned in the literature to explain the cyclic character of the $O-C$ diagrams. Finally the binary explanation can only be accepted with certainty when several cycles have already been observed.

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