THE VARIABLE PERIOD OF W DELPHINI

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The tendency for the period changes in eclipsing binaries to appear sinusoidal led astronomers in the first half of this century to suggest apsidal motion or orbital motion around a third body as explanations. Clear-cut examples of both of these phenomena have been found; but as more and more times of minimum are observed and the base line in time gets longer, it has become clear that in the large majority of cases the period variations are not really sinusoidal or even periodic.

Among the Algol-type binaries (remnants of post-main-sequence mass exchange in a close binary system) there are very few certain examples of apsidal motion or third bodies. There are several reasons for this. First, there are theoretical grounds for expecting little or no orbital eccentricity in Algol-type binaries and hence no line of apsides to rotate. Second, it is difficult to get accurate times for the shallow secondary minima in order to check if they are varying out of phase with the times of primary minima and thus indicative of apsidal motion. Third, most of the Algol-type binaries seem to be experiencing cyclical (but not periodic) period changes as a result somehow of the mass exchange, which virtually all of them are still undergoing. These cyclical changes are large and, even if not responsible for all of the period variation in a given binary, can easily mask the evidence of any true apsidal motion or orbital motion around a third body.

Virtually all of the many Algol-type binaries once believed to be experiencing apsidal motion or motion around a third body have, one by one, proven to be false alarms. The above-mentioned cyclical activity has been mistaken for periodicity when less than one complete "cycle" was observed. Among the precious few serious candidates remaining, the favorite has been W Delphini (203317). The purpose of this paper is to collect recent times of minimum for W Del and show that the period variation, previously thought to be sinusoidal, is not.

Plavec (1959, 1960) analyzed 116 times of primary minimum which were obtained between 1896 and 1956, grouped them into 31 weighted normals, and came to the conclusion that they could be represented remarkably well by the following ephemeris, in which the period varies sinusoidally every 51 years or 3870 cycles:

$$JD = 2418048^{d}.61866 + 4^{d}.80604313E + 0^{d}.0555 \sin(0°.09303E + 81°.08).$$

Plavec was aware of the danger in concluding firmly that the period variation really is sinusoidal, and he stressed this in his papers. After that, Illés-Almár and Almár (1963) interpreted the 51-year variation as the result of orbital motion around a third body of 1.9 solar masses or more, but this interpretation was criticized by Schneller (1964). More recently, Heasley (1971) discussed the theoretical implications of a 51-year apsidal motion period, not mentioning the possibility that apsidal motion might not be causing the period variation.

I have located ten times of primary minimum observed since Plavec completed his search; they are listed in Table 1 along with the O-C residuals computed with the linear part of Plavec's ephemeris. The first two of these times are based on photoelectric observations, the last eight on visual estimates. These residuals, along with the residuals of Plavec's 31 normals, are plotted in Figure 1. The curve in Figure 1 represents Plavec's complete ephemeris,

If the period variation is really sinusoidal, the residuals of the new times would have to fit the sine curve, but they clearly do not. The last time of minimum has a residual above the sine curve of 3.5 hours.

Thus the period variation in W Del cannot be due to apsidal motion or to a third body but is more probably of the sort caused by mass exchange. To my knowledge the only Algol-type eclipsing binary which can still be considered a good candidate for apsidal motion or orbital motion around a third body is Algol itself (Herczeg and Frieboes-Conde 1968). There is as yet, however, no satisfactory theoretical explanation for the cyclical variation itself, i.e., the occurrence of alternate increases and decreases, since the mass exchange should be causing the period to increase steadily. Therefore much work remains before we can say that the period variation of W Del is really understood.

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TABLE I
Times of Primary Minimum for W Delphini

JD (hel.)	E	O-C	Year	Reference
2438618.5574	+4280	$+0^d.074$	1964	Walter (1970)
2439051.079	4370	0.052	1965	Hall (1967)
2439358.695	4434	0.081	1966	Robinson (1967)
2440752.471	4724	0.105	1970	Oburka (1971)
2440752.472	4724	0.106	1970	Oburka (1971)
2440800.528	4734	0.101	1970	Diethelm et al. (1970a)
2440853.389	4745	0.096	1970	Diethelm et al. (1970b)
2440853.406	4745	0.113	1970	Diethelm et al. (1970b)
2440853.419	4745	0.126	1970	Diethelm et al. (1970b)
2441569.543	+4894	$+0^d.149$	1972	Diethelm et al. (1972)

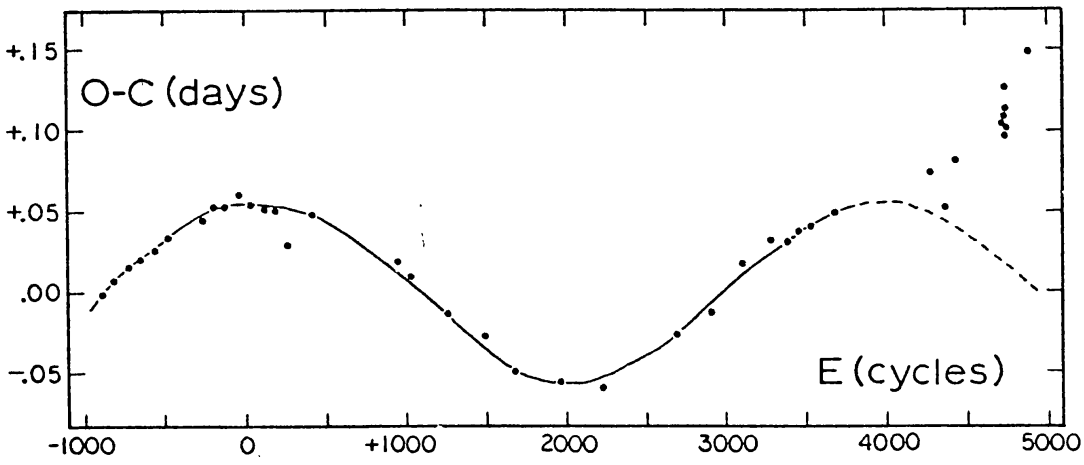

Figure 1. W Delphini - O-C Residuals vs. Cycles.