PHOTOMETRY OF APSIDAL MOTION STARS - A PROGRESS REPORT

C.D. Scarfe
Climenhaga Observatory, Department of Physics
University of Victoria
Victoria, B.C.
Canada

ABSTRACT. Times of minima of apsidal motion binaries have been obtained at this observatory and at Siding Spring and Cerro Tololo Observatories. This paper discusses the results for CW Cephei, DR Vulpeculae, V477 Cygni and the seldom-observed southern system YY Sagittarii.

A long-term project ideally suited to small telescopes, timing the minima of eclipsing binaries, has been in operation at the Climenhaga Observatory since 1969. All observations are photoelectric, and made differentially with respect to nearby comparison stars. They are reduced by the method of Kwee and van Woerden (1956).

Among the systems which have been studied are several with eccentric orbits which show advance of the line of apsides. In addition several similar objects have been observed from Siding Spring Observatory in 1978 and from Cerro Tololo Interamerican Observatory in 1980. In this paper I shall discuss the three most-frequently observed northern systems, CW Cephei, DR Vulpeculae, and V477 Cygni, and the southern system YY Sagittarii.

In order to treat the apsidal motion separately from other causes of period variation, use was made of its different effects on primary and secondary minimum. For each system, each season in which both eclipses were observed yields a value of the left side of the equation

$$\frac{\pi}{P_s}(t_2 - t_1 - \tfrac{1}{2}P_s) = (2 + \cot^2 i)\, e \cos\omega - \tfrac{1}{3} e^3 \cos 3\omega \qquad (1)$$

In this equation, which is valid for small e and $i \simeq 90°$, P_s is the mean sidereal period, t_1 and t_2 are times of adjacent primary and secondary minima, e and i are the orbital eccentricity and inclination, and ω is the instantaneous longitude of periastron. This equation was used to determine e, the apsidal period U, and the time of conjunction of the apsidal line ($\omega = 90°$ or $270°$). From these an ephemeris was calculated to fit all the available times of minima, adjusting P_s and initial epoch by least-squares.

For CW Cephei we have obtained observations of six primary and

J. B. Hearnshaw and P. L. Cottrell (eds.), Instrumentation and Research Programmes for Small Telescopes, 319–320.

seven secondary eclipses. Together with data from the literature these provide nine epochs spread over thirty years for use with equation (1). The values of e and U derived are given in Table I, the latter being slightly longer than that found by Soderhjelm (1976). The r.m.s. residual for all known photoelectric minima from the resulting ephemeris is $0^d.0019$. Thus there is no evidence for any period change other than that due to apsidal motion.

For DR Vulpeculae we have obtained observations of ten primary and seven secondary minima; there are eight epochs, spread over 21 years, at which $t_2 - t_1$ has been determined. Equation (1) yields the values of e and U given in Table I, which are in reasonable agreement with those of O'Connell (1972) . However when the apsidal terms are subtracted from the individual times of minima, it is clear than the mean period has increased over the last two decades. The data are insufficient to determine whether this increase has been continuous or abrupt.

For V477 Cygni, we have obtained observations of nine primary and four secondary minima since those listed by Scarfe et al (1976). There are now a dozen seasons in which $t_2 - t_1$ has been determined; for these equation (1) gives the results in Table I, which agree well with those of O'Connell. The r.m.s. residual in this case is $0^d.0012$.

For YY Sagittarii one primary minimum was obtained at SSO and primary and secondary minima on consecutive nights at CTIO. The latter may be combined with the data of Keller and Limber (1951) to obtain U = 238 yr, which is too uncertain to yield a reliable apsidal constant.

Apsidal constants, corrected for the general relativistic effect, are included in Table I. For DR Vul it was necessary to estimate masses from the light ratio and spectral type, since no spectroscopic solution has been published. Possibly DR Vul's extra period change is a light-time effect, and if so the third body may contribute to the apsidal motion, and k may thus be incorrect.

Table I

Star	CW Cep	DR Vul	V477 Cyg	YY Sgr
P_s (days	2.729	2.251	2.347	2.628
e	0.0285	0.0947	0.3045	0.163
U (years)	45.0	36.1	350	238:
k	0.0086	0.0092	0.0056	

References

Keller, G. and Limber, D.N. 1951. Ap. J. 113, 637.
Kwee, K.K. and van Woerden, H. 1956. B.A.N. 12, 327.
O'Connell, D.J.K. 1970. Vistas in Ast. 12, 271.
O'Connell, D.J.K. 1972. Specola Vaticana 8, 319.
Scarfe, C.D., Barlow, D.J., and Niehaus, R.J. 1976. Ap. and Sp. Sci 39, 129.
Soderhjelm, S. 1976. Ast. and Ap. Supp. 25, 151.

https://doi.org/10.1017/S007418090015168X Published online by Cambridge University Press