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A 100 YEAR PERIOD STUDY OF V523 CASSIOPEIAE: A TRIPLE STAR SYSTEM?

SAMEC, RONALD G.[1]; BANKS, DANIEL F.[1]; HERNANDEZ, REY[1]; FAULKNER, DANNY R.[2,4]; WILLIAMS, DAVID B.[3]

[1] Astronomy program, Dept. of Physics, Bob Jones University, Greenville, SC 29614 USA, email: rsamec@bju.edu

[2] The University of South Carolina – Lancaster, Box 899, Lancaster, SC 29721 USA, email: faulkner@sc.edu

[3] P.O. Box 58, Whitestown, IN 46075, USA, email: DBwilyumz@aol.com

[4] Visiting astronomer, Lowell Observatory, Flagstaff, Arizona

V523 Cassiopeiae [WR16, CSV 5867, GSC 3257-167] has figured prominently in studies of very short period K-type non-degenerate eclipsing binaries over the past 15 years or so. At 336.5 minutes, its period is one of the shortest among late type, W UMa contact binaries. V523 Cas is also noted for variations in its light curve and for large period changes. One of the authors (DBW) has acquired 50 times of low light found from a search of the archival photographic Harvard/SAO plate stacks. The timings cover the interval from 1901 to 1942 and greatly extend the baseline over which the period behavior of V523 Cas may be studied. In addition, seven mean epochs of minimum light were determined from observations made during three primary and four secondary eclipses from 1999 observations at Lowell Observatory carried out by DRF. These times of minimum light are announced in Table 1 (available electronically through IBVS Web-site as file 5175-t1.txt) with standard errors in parentheses. Also listed is the starting epoch of our light elements presented below. These were combined with the over 400 timings of minimum light available in the literature (see Table). These span the interval from 1963 to 2001, yielding a hundred year period history (with a 21 year gap) spanning nearly 185,000 orbits. This is probably the longest period study ever undertaken for a W UMa binary. The amazing results are reported here.

A least-squares linear fit to all available timings resulted in the following linear light elements:

$$\text{J.D. Hel. Min I} = 2446708\overset{\text{d}}{.}7706(27) + 0.23368973(8) \times E, \tag{1}$$

where the probable errors are in parentheses. The $O-C$ residuals for Equation (1) are plotted in Figure 1. The $(O-C)_1$ residuals in Table 1 calculated with these light elements. Mathematically, the data strongly suggest the sum of a sinusoidal variation and a continuous period increase. We fitted the data to just such an equation. This equation gives a final ephemeris of:

$$\begin{aligned}\text{J.D. Hel. Min I} = 2446708\overset{\text{d}}{.}800(9) + 0.23369099(18) \times E +\\ + 1.02(9) \times 10^{-11} \times E^2 + 0.036(5) \times \sin[4.0(0.3) \times 10^{-5} \times E - 1.0(0.1)].\end{aligned} \tag{2}$$

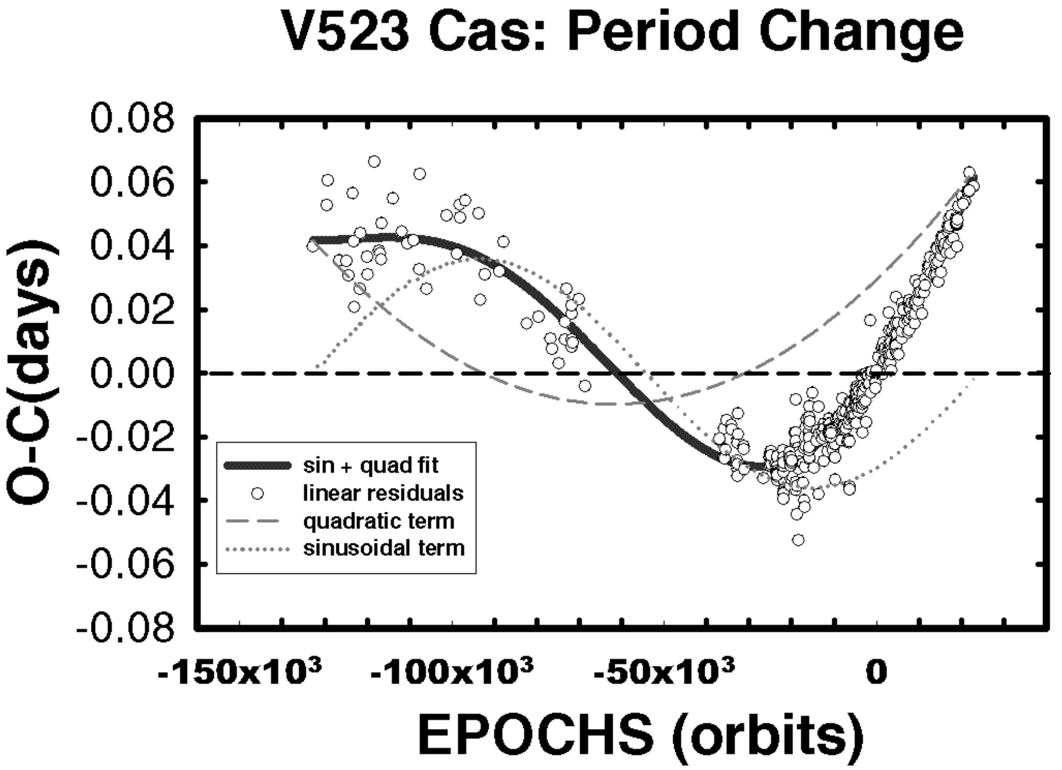

Figure 1. $O - C$ residuals calculated from Equation (1) for V523 Cas overlain with the sum of a sinusoid quadratic ephemeris. The sinusoid and quadratic curves also are shown separately

The fit is plotted with the data in Figure 1, and the $(O-C)_2$ residuals for Equation (2) are given in Table 1. The correlation coefficient for this excellent fit, $R = 0.97$ (a perfect curve fit would yield $R^2 = 1$). The quadratic term, $1^{\mathrm{d}}.02 \times 10^{-11} \times E^2$, may be due to mass accretion onto the primary component or some as yet unexplained physical process causing the binary components to continuously separate. Such a continuous period increase or decrease is not unusual for short period contact binaries. However, the sinusoidal behavior with an amplitude of 0.036(5) d (light time: 6.22 AU) is seen only in systems that have a third body present in the system. Assuming that this is the case, and that the inclination from our orbital solution for the close pair is the same as the larger orbit, from Kepler's third law and Equation (2) we obtain a mass for the third star of 0.37 solar masses. This is similar to the masses of the stars that comprise the contact binary. Milone, Hrivnak, and Fisher (1985) point source model gives a total mass of $\sim$ 0.88 solar masses, our simultaneous (using our 1999 light curves) Roche-lobe model yields 0.96. The period of the larger system is 101(8) years. If there is a third member of this system as we suggest here, then from Figure 1 we see the companion should be near greatest separation now. The size of the orbit and the distance of the system result in a maximum angular separation of about $0''.3$. The expected V magnitude of the companion should be about 15.0. With adaptive optics on a large telescope with good seeing it should be possible to resolve the companion, if it exists.

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