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THE PERIOD VARIABILITY OF SX CASSIOPEIAE

Photoelectric observations of the complicated $36^{d}.57$ eclipsing binary, SX Cas were carried out at Villanova University Observatory using the 38-cm reflector. The observations were obtained during February and March 1979 at time when the star was being studied in the UV with the IUE satellite by Drs. R.H. Koch and M. Plavec. During early February, 1979 we were fortunate to obtain four consecutive clear nights during the primary eclipse. The duration of the eclipse is about 4 days. Additional data were collected on three nights outside eclipse and on one night during the following eclipse in March. The observations were made using a photoelectric photometer equipped with a thermoelectrically cooled RCA C31034 gallium - arsenide multiplier photocell and a microprocessor-controlled integrating system. Pairs of wide-and narrow-band interference filters centered near the OI λ 7774 triplet and the Hα feature were used. Only the observations obtained through the wide bandpass filters were used in this study to determine the time of minimum light. The results of the full photometric study will be published later. The characteristics of the wide-band filters are: OIw (λ max = 7790Å; HWFH = 185Å), Hαw (λ max = 6595Å; HWFH = 270Å). The wide-band filters are broad enough so that the line feature does not significantly contribute to the measure.

The present observations obtained during primary eclipse were combined using the light ephemeris of Koch (1972),

$$\text{Pri. Min.} = \text{HJD}2433963.240 + 36.56717 \cdot E \quad . \qquad (1)$$

The phase at which mid-eclipse occurred was found by comparing our observations with a mean V light curve of SX Cas obtained from the observations given by Koch. The λ7790 and λ6595 observations were each scaled to the V light curve and the phase at which primary minimum occurred was found using the method of Szafraniec (1948). The time of primary eclipse determined in this manner was HJD2443909.11 and has an estimated uncertainty of about ±0.04 day. The O-C for this timing was found to be $-0^{d}.41$ when eq. 1 is used.

Although a recent period study of SX Cas has been published by Whitney (1978), only data up to 1966 were used and no new light ephemeris was derived. The relatively large O-C found here indicates that the old light ephemeris for SX Cas is no longer adequate and a new period study was undertaken.

Compilations of times of minimum light for SX Cas have been published by Dugan (1933), Koch (1972), and Whitney (1978). The most recent timing included in these compilations was for 1966. In addition to these timings, two visual timings of primary minimum by Samolyk and Wedemayer are listed by Baldwin (1978). These are for the same night and have been combined yielding: HJD2442592.64. Visual and photographic timings from Table I of Dugan, and also from Whitney's Table I, and photoelectric minima given in Table II of Whitney were combined with the present photoelectric timing and the visual estimate obtained from Baldwin. Fifty six timings of minimum light were accumulated and were assigned weights based upon weighting criteria given by Dugan and Whitney. Residuals were first computed from eq. 1. These residuals were then subjected to least squares polynomial fitting. A quadratic fit was found to be inferior to a cubic one and the latter is shown among the residuals in Figure 1. The improved ephemeris is:

$$\text{Pri. Min.} = 2433963.297 + 36.56667\,E - (2.78 \times 10^{-6})\cdot E^{2} - (2.34 \times 10^{-9})\cdot E^{3} \quad (2)$$

If the small cubic term is neglected, the change in period may be found:

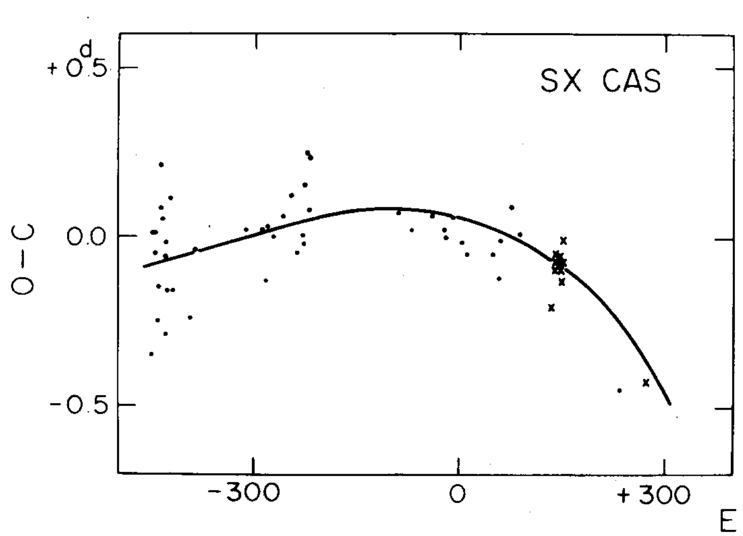

Figure 1. The (O-C) diagram from EQ. 1 for SX Cas. Small circles refer to visual or photographic measures and the crosses refer to photoelectric determinations. The curve represents EQ.2.

$\Delta P/E = -0.24$ sec/cycle

$\Delta P/P = -7.60 \times 10^{-8}$.

Alternatively it could be assumed that the period change was more abrupt and took place during the early 1960's. Two linear ephemerides were computed from the timings obtained before and following 1960,

$$\text{Pri. Min.} = 2433963.267 + 36.56727 \cdot E \qquad (3)$$

(1908-1960)

$$\text{Pri. Min.} = 2439009.525 + 36.56375 \cdot E. \qquad (4)$$

(1965-1979)

By subtracting the first period determination given in eq. 3 from that of eq. 4, we obtain,

$$\Delta P = 0^{d}.00352 = 304 \text{ sec.}$$

Equation 4 can be used to compute eclipse predictions for SX Cas in the near future.

In a recent IUE study by Plavec and Koch (1978) , SX Cas was one of several close binaries displaying strong UV emission lines indicative of hot plasmas. It is proposed by these authors that these systems, which include RX Cas, SX Cas, W Cru, V 367 Cyg, β Lyr, RW Per, and W Ser, contain hot components having optically and geometrically thick disks. These systems may be in the rapid stage of mass transfer or mass loss which could lead to the formation of an accretion disk about one of the components. The relatively large value of $\Delta P/P = -7.6 \times 10^{-8}$ found in the present study for SX Cas as well as the large values of $\Delta P/P$ found in the recent period studies of β Lyr (Herczeg 1973) and of W Ser (Koch and Guinan 1978) appear to be in accord with mass transfer rates of $\sim 10^{-5} M_{\odot}$/ year. The rate of period change found SX Cas is comparable in magnitude but opposite in sign, however, to those found for β Lyr and W Ser. For β Lyr and W Ser the period appears to be increasing while the period of the SX Cas is decreasing. This may indicate that SX Cas is at a different stage of stellar evolution than the other two systems. If the rate of period decrease for SX Cas is assumed to be steady (with conservation of mass and angular momentum), the decrease in period could indicate that mass transfer is taking place with the mass flow from the more to the less massive component (Kruszewski 1966). Under this interpretation SX Cas may be in the rapid mass transfer stage prior to mass-ratio reversal. β Lyr and W Ser as well as many other close binary systems appear to be in the mass transfer stage after mass reversal has taken place - i.e. where the flow is from the less to the more massive component. The spectrographic study of SX Cas by Struve (1944) indicates the existence of a stream of gas receding from the G-type component and flowing toward and around the hotter component. In a recent spectrographic study by Andersen (1973) the spectrum of the cooler component was detected and was found to have a radial velocity amplitude of two to three times greater than the hotter star. This would imply that the mass of the G-type component is approximately 1/2 to 1/3 the mass of the hotter star. Thus, the negative value of $\Delta P/P$ found here for SX Cas, when interpreted in terms of mass transfer from the more to the less massive star, is not in agreement with that indicated by the spectrographic studies. It is apparent that SX Cas is a very complex system and more observations are needed to clarify its evolutionary state.

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References:

Andersen, J., 1973, Publ. Astron. Soc. Pacific, 85, 191.

Baldwin, M. E., 1978, Journal of A. A. V. S. O., Vol. 7, No. 1.

Dugan, R. S., 1933, Princeton Obs. Contr. No. 13.

Herczeg, T. J., 1973, I. B. V. S., No. 820.

Koch, R. H., 1972, Astron. J., 77, 500.

Koch, R. H., and Guinan, E. F., 1978, I. B. V. S., No. 1483.

Kruszewski, A., 1966, Adv. in Astronomy and Astrophys., Vol. 4, 233.

Plavec, M. , and Koch, R. H., 1978, I. B. V. S., No. 1482.

Struve, O., 1944, Ap. J., 99, 89.

Szafraniec, R., 1948, Acta Astron., 4, Series C, 81.

Whitney, B. S., 1978, I. B. V. S., No. 1430.