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σ^2 CrB: A NEW VARIABLE STAR, SHOWING POSSIBLE RS CVn-TYPE AND δ Sct-TYPE VARIABILITY

The bright star σ CrB = HR 6063 + 6064 = ADS 9979AB was observed photoelectrically to search for variability. It appears as CSV 101569 in the (First) Catalogue of Stars Suspected of Variability. The brighter component (σ^2 CrB = HR 6063 = ADS 9979A) is a non-eclipsing SB2 RS CVn-type binary and we suspected the characteristic distortion wave may be present in its light curve.

Tanner (1949) redetermined the spectroscopic orbit with the correct orbital period of $1\overset{d}{.}14$. According to Petrie (1950) the two stars in the SB2 system are comparable in luminosity, with $\Delta m = 0\overset{m}{.}2$. Young and Koniges (1977) found strong H and K emission from both. Spangler et al. (1977) have detected radio emission from σ CrB. The spectral classification of σ^2CrB, apparently a composite of the SB2 system, appears in the literature as dF6 or F8.

We compute phases with the ephemeris

$$JD(hel.) = 2423869.105 + 1\overset{d}{.}139789\ n$$

of Tanner, where the initial epoch is his T_0, an epoch of maximum radial velocity for the more massive star. The accumulated effect of the $\pm 0\overset{d}{.}000007$ uncertainty in Tanner's period generates an uncertainty of $\pm 0\overset{P}{.}1$ in our computed phases.

Altogether 62 differential magnitudes were obtained on nine different nights between JD 2443696.6 and 2443758.6. The telescope was a 12-inch Cassegrain reflector and an unrefrigerated 1P21 photomultiplier at -700 Volts was used with a filter chosen to approximate V of the UBV system. The diaphragm, about 1 arc-minute in diameter, included σ^1 CrB and also ADS 9979D ($m_V \sim 12\overset{m}{.}5$) but not ADS 9979C ($m_V \sim 10\overset{m}{.}0$). The comparison star was HR 6043= ADS 9958AB and the diaphragm included both components of that visual system also. The necessary corrections for differential atmospheric extinction were applied but were very small.

There is indication of a sinusoidal variation with an amplitude of approximately $\Delta V = 0\overset{m}{.}05$ and a minimum at approximately $0\overset{P}{.}4$, although there is considerable scatter about such a sine wave, moreso than would be expected from observational uncertainty. On six of the nine nights observations were obtained in the following sequence: about 4 observations made within an interval of ~5 minutes followed by 4 more observations made ~1 hour later. The scatter within each group of 4 suggests an uncertainty of only about $\pm 0\overset{m}{.}005$ for the mean. (Comparable precision was characteristic of photometry of HR 7275 and HR 8575 which we obtained on most of those same nights). The difference between two means, however, ranged between $0\overset{m}{.}013$ and $0\overset{m}{.}040$. Also we note that the maximum deviation of the means from the sine wave was $0\overset{m}{.}025$. We conclude that this short timescale variability, if real, could be described as resulting from a cyclical variation having a period of $\sim 0\overset{d}{.}1$ and a total amplitude of $\sim 0\overset{m}{.}05$. The simplest explanation would be δ Scuti-type variability in one star of the SB2 system. The period is quite typical of known δ Scuti variables. If one removes the light of σ^1CrB (about 1^m fainter in V than σ^2 CrB) and also the light of the comparably bright companion star in the SB2 pair, one finds an intrinsic amplitude of $0\overset{m}{.}12$ for the suspected δ Scuti-type variability. Although it is possible that the comparison star HR 6043 or σ^1 CrB could be variable, neither is likely to be a δ Scuti variable. HR 6043 is spectral type gK2 and σ^1CrB is dG1 whereas σ^2CrB is F-type.

Returning to the $1\overset{d}{.}14$ sinusoidal variation, we feel this is most likely a result of the distortion wave characteristic of other RS CVn variables. Clearly this is not the ellipticity effect, because the light varies as a function of θ, not 2 θ. We can also show, by computing an upper limit, that this is not the differential reflection effect. A total mass of about 2.5 $M_\odot$ for the SB2 system would imply $i = 30^\circ$. We recall that the two stars are roughly comparable in luminosity. The maximum differential reflection effect would occur if one star had the smallest possible radius (main-sequence) and the other star had the largest possible radius (filling its Roche lobe). With these assumptions, reflection would produce a variation of total amplitude $\Delta V \leq 0^m_.017$. The inclusion of σ^1CrB (about 1^m fainter than σ^2CrB) in our photometry reduces this limit to $\Delta V \leq 0^m_.012$. This is considerably smaller than our observed amplitude of $\Delta V = 0^m_.05$. The reflection effect should produce a minimum of light at one of the two conjunctions: either $0^P_.25$ or $0^P_.75$ based on Tanner's ephemeris. This is apparently not consistent with our minimum at $0^P_.4$, although the $\pm 0^P_.1$ uncertainty in our phases prevents a firm conclusion in this respect.

The proposed δ Scuti variability would be easier to understand if one component of the SB2 pair were somewhat earlier than the composite type (which is F6 or F8). Likewise, the RS CVn-type distortion wave would be easier to understand if the other component were later than the composite type.

The time is ripe for more observational work on σ CrB, none of it difficult for such a bright star. (1) Photometry of σ CrB should be repeated with continuous observation over intervals longer than the suspected $0^d_.1$ period of the suspected δ Scuti variability, not only to confirm the reality and nature of that variation but also to remove that effect and thus define better the distortion wave. (2) A check star should be observed to exclude with certainty the possibility that our comparison star HD 6043 is variable. (3) A classification spectrum should be obtained at quadrature in order to determine separate spectral types for the two components of the SB2 system. (4) An up-to-date spectroscopic orbit should be obtained in order to remove the $\pm 0^P_.1$ uncertainty in computed orbital phases and thereby make it possible for subsequent photometry to ascertain whether the distortion wave is migrating with respect to the orbital period.

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