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DELTA CAP : A POSSIBLE RS CVn BINARY

The eclipsing binary δ Cap(= BD - 16° 5943) was known to be a single line spectroscopic binary. Slipher (1906) first detected variable radial velocity in δ Cap. Crump (1921), Luyten (1936), Stewart (1958) and Batten (1961) derived its spectroscopic elements, and changing features were noticed by some authors. Eggen (1956), Wood and Lampert (1963), Dorren et al. (1980) and Ohmori (1981) attempted its photometry, but none of these photometries were satisfactory.

The author for the first time attempted its photometry in all the three (UBV) filters through the 38 cm reflector of the Uttar Pradesh State Observatory using a 1P21 photomultiplier cooled to -20°C, and employing d.c. techniques. Observations of eight nights were secured in the time interval September 1979 to October 1982. The stars γ Cap and ε Cap were used as the comparison and the check stars, respectively.

Photometrically, there are six criteria for deciding whether a certain object is an RS CVn variable or not. These are : (a) light curve variations, (b) colour index outside eclipses, (c) variation of the primary minimum depth, (d) displacement of the secondary minimum, (e) orbital period between 1 day to 2 weeks, and period variations, and (f) the primary and the secondary components belong to the spectral types F-G V-IV and G-K IV-III, respectively.

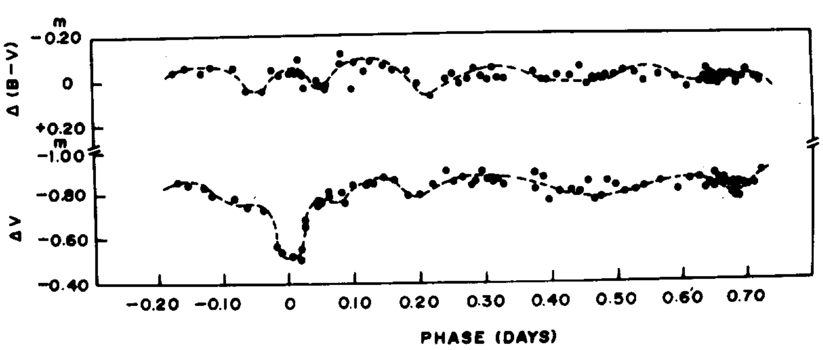

Figure 1

Smoothened V light curve of δ Cap is given in Figure 1, which shows light curve variations outside the eclipses.
The colour index also shows variation outside the eclipses, and throughout the cycle. These variations may also be caused by the intrinsic variability of one of the components of δ Cap or due to the variability of the comparison star. We will undertake the discussion of these possibilities later. The depth of the primary minimum in V filter comes out to be 0.32 magn.
Wood and Lampert (1963), and Ohmori (1981) gave the depths of the primary minimum in V filter as 0.16 magn. and 0.15 magn., respectively, few hundredths magnitude deeper than that given by Eggen (1956).
Thus, it is apparent that the depth of the primary minimum shows some variation. Dorren et al. (1980) gave the depth of the primary minimum in H_α as $0^m.18$.

During the course of our observations, one primary minimum (J.D. 2444163.272) and one secondary minimum (J.D. 2445261.168) were observed, which showed the shifts of $-0^d.001$ and $0^d.046$ respectively, using the ephemeris : J.D. 2421424.847 (Luyten, 1936) + $1^d.0227789$ (corrected) E. The shift of the primary minimum is within the graphical error of determination of minima ($\pm$ $0^d.001$), thus it is apparent that the secondary minimum shows a considerable displacement from its position. On the other hand, Dorren et al. (1980) found that the secondary minimum occurred close to phase 0.5. In this light too, present displacement of the secondary minimum is important.

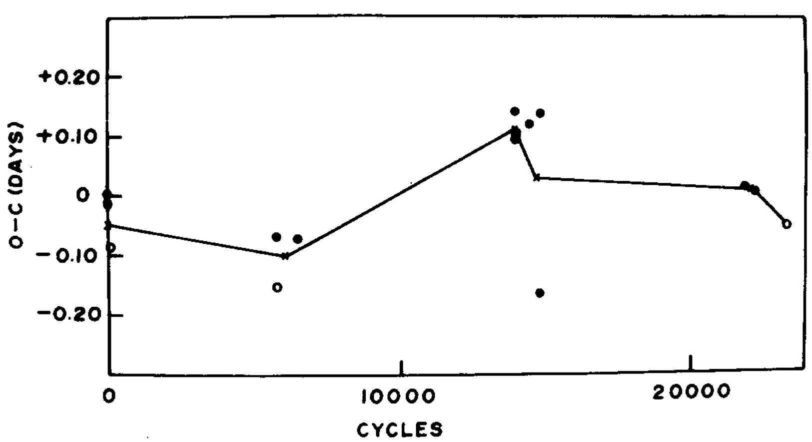

Figure 2

The O-C diagram (Figure 2) using available times of minima, based on the above ephemeris, clearly indicates sudden period changes, which fact is also apparent from the increased corrected period in comparison with earlier ones. Wood and Lampert (1963) did not rule out the possibility of a period change, either.

The spectral types at maximum, at the tip of the primary and at the tip of the secondary minimum appear to be FOIV, F1 IV-III and F1 IV-III respectively. Rough estimates suggest that the secondary eclipse is an occultation. This finding of ours is in agreement with that of Dorren et al. (1980). However, it is difficult to decide whether the eclipses are total or partial. If we assume that the eclipses are total, the brighter component appears to be of F1IV-III spectral type, which is in the line of earlier determinations. We shall now discuss the possibility of intrinsic variability and the variability of the comparison star. The Δ (B-V) colour curve (Figure 1) shows colour variation throughout the cycle, and are supposed to be caused by the intrinsic variability of one of the components. The mean amplitude (max. to min.) of various dips of V light curve is of the order of 0.06 magn., while the mean amplitude of the dips of the colour curve is nearly 0.1 magn., which is not possible. In addition, some of the dips in V light curve and Δ (B-V) colour curve do not correspondingly occur, but are seen shifted. These facts rule out the possibility of intrinsic light variations present in δ Cap. We, checked the variability of the comparison star against the check star, and it was found that the comparison star showed stable behaviour, within error of observations ($\pm$ $0^m.02$). Thus, it is evident that whatever light and colour variations are present in δ Cap, are due to some other phenomenon like star spot activity etc. Now we will assess the spectral type of the secondary component.

Batten (1961) stated that the secondary component must be at least three magnitudes fainter than the primary. He estimated the absolute visual magnitude of the primary component as + 2.2, which corresponds to a normal A6 star (Arp, 1958). Thus, vide his statement, the absolute visual magnitude of the secondary component must be 5.2, which indicates that it is closer to a normal G6 star. Now, on the other hand, if we stick to our assumption that the secondary eclipse is a total occultation, then for the normal (or Main Sequence) primary (F1), the absolute visual magnitude will be 3.0. If we consider Batten's (1961) statement as taken for granted then the absolute visual magnitude for the normal secondary component must be 6.0, which belongs to K1 (Te = 4920°K) type. Now, from another angle, we see that the depth of the secondary minimum (0.07 magn.) is four-and-half times less than the depth of the primary minimum 0.32 magn.), which fact shows that the secondary component is considerably fainter than the primary. In addition Dorren et al. (1980) estimated the temperature of the secondary component as $4700^{o}K$, which is near the temperature of a K2.5V star, while our above estimate shows it to be $4920^{o}K$(K1V). Thus, it is apparent from the above discussion that the primary component belongs to early F type, while the secondary component belongs to late G or early K type. The shallower depth of the secondary minimum may cause some uncertainty in the spectral types of the components, but that will be not more than one sub-spectral class. Since, the maximum belongs to IV luminosity class, and, thus, one component may belong to IV-III luminosity class (Pr:F1IV-III).

Thus, it is apparent from the above discussions that δCap satisfies all the photometric properties of an RS CVn type variable. It is also evident from the above discussions that the light and colour variations are real and sometimes greater than the 3 σ level. Wood and Lampert (1963) stated that the November observations appeared below the September observations, which fact suggests that the light curve is variable in intensity. A similar small difference between the observations on two nights was found by Eggen (1956). Dorren et al. (1980) found light variations on the time scale of several hours. In our observations of two nights falling around phase 0.68 some variation of light is seen. Thus, it seems clear that the light curve of δ Cap shows variation.

Considerable scatter was found in the observations of Dorren et al. (1980). They suspected that this scatter was intrinsic to δCap but could not ascertain it. Our observations also show some scatter around the secondary minimum in V filter, but we have already negated the possibility of these intrinsic light variations. Dorren et al. (1980) also found relatively large scatter in α - index, which is a measure of net strength of H_{α} line, and phase dependent variation of Δα . They suspected the presence of a gas stream or a hot (or cool) spot on the surface of the hotter component. In our observations, although two dips (max. to min.) are visible around phases 0.19 and 0.68, but the dip around $0^{P}.19$ is definitive, hence we feel that cool apots may be present in the system, and may be responsible for the light curve variations.

From the whole discussion, we feel that δ Cap is a possible RS CVn type variable. It is desired to confirm its nature as an RS CVn variable from future observations in different filters.

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