IS HD 164270 A LONG-PERIOD ECLIPSING BINARY?

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1. INTRODUCTION

The WC star HD 164270 (=WR 103 in the catalogue by van der Hucht *et al.*, 1981) is one of the stars to which Smith (1968) ascribed variability, although she was not able to investigate the light variations completely. The star has been regarded as a single star (i.e. no evidence of absorption lines) but it has been proposed by e.g. van den Heuvel (1976) that "single" WR stars might have collapsed companions. Eclipses by such short-period companions should be observable. Thus we designed an observational programme to look for hitherto unobserved companions. The programme contained 16 "single" WR stars. Some of them, including WR 103, had previously shown light variations as mentioned.

Bad weather occurred during the twenty nights of observation in June, 1980. The prospects to find periodic, small-scale variations were not good and we decided to take up the programme again in 1981. This was also done. In the meantime we had discovered that the star WR 103 during the observations in 1980 decreased its brightness with about one magnitude. At about the same time Isserstedt and Moffat (1981) published their investigation of WR 103, indicating that the star might have a compact companion with a period of 1.756 days.

2. OBSERVATIONS

In 1980, the observations were done between June 4 and June 24 with the 0.5 m telescope at European Southern Observatory. A standard one-channel photometer was used together with three especially selected filters, called v, b' and b, see Figure 1 for a description of the filter profiles compared with the spectrum of a WC9 star. Two stars were used as comparison stars, HD 164152 (A0, V = 8.9) and HD 163868 (B3, V = 7.4), called c1 and c2 respectively. Each observation consisted of the sequence

c1 - c2 - WR - c1 - c2

and this cycle took about 20 minutes. The arithmetic means were calcula-

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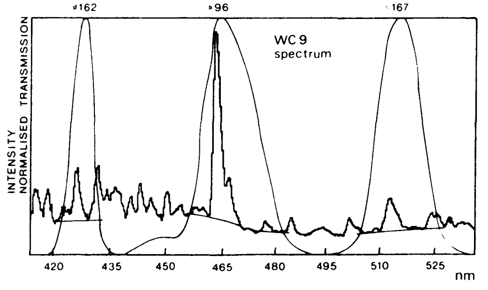

Figure 1. Filter transmission profiles (from left to right b, b', v) compared with a WC9 spectrum. The star is not WR 103 but WR 80 (= LSS 3871). The upper numbers are from ESO filter stock.

ted for each of the two comparison stars and these were directly compared with the WR star without any correction for extinction or instrumental properties. As said earlier, the weather was not favourable. Some observations had to be totally excluded, and the observations presented here have therefore been carefully studied in order to avoid all weather-depending influences in Δm as far as possible.

The observations are shown in Figure 2. Comparisons are made between the WR star and c1 and between c1 and c2 and these are shown as Δm versus Julian Day number. As for the observations in 1980 (left in Figure 2), it can be seen that the dispersion in Δm for the two standard stars is normal, about $0^m.01$, with an only exception at JD 2444412.85. This point is deflected from the mean value more than the other, presumably being an weather effect which could not be reduced further. However, the conspicuous thing in the 1980 observations is the drop in the brightness of the WR star, being at minimum around JD 2444412. In the lower part of Figure 2 the corresponding colour curves are shown. The scale for Δm is here doubled and there is a considerable spread even for points obtained during the same night. The standard deviation in Δm for the standard stars is about $0^m.005$, that is much less than the variations shown in the 1980 observations, which means that there are rapid colour changes in the WR star even within a couple of hours.

Similar observations were then done between April 6 and 16 1981 with the same set of equipment as in 1980. These observations are also shown in Figure 2 (right). The WR star has now regained its brightness as it was during the first night in June 1980. Compared with Δm for c2 - c1, where the dispersion is very small, the WR star seems to flicker around its mean value in an irregular way. It should be noted that c2 - c1 in 1981 is $0^m.06$ less than in 1980, presumably due to a change in brightness of the star c2 occurring between our two observation runs. The colour curves of the WR star for 1981 show the same behaviour as the light curve. No long-term variation but a considerable spread around a mean value very close to the undisturbed value from the first night in the 1980 observations is seen.

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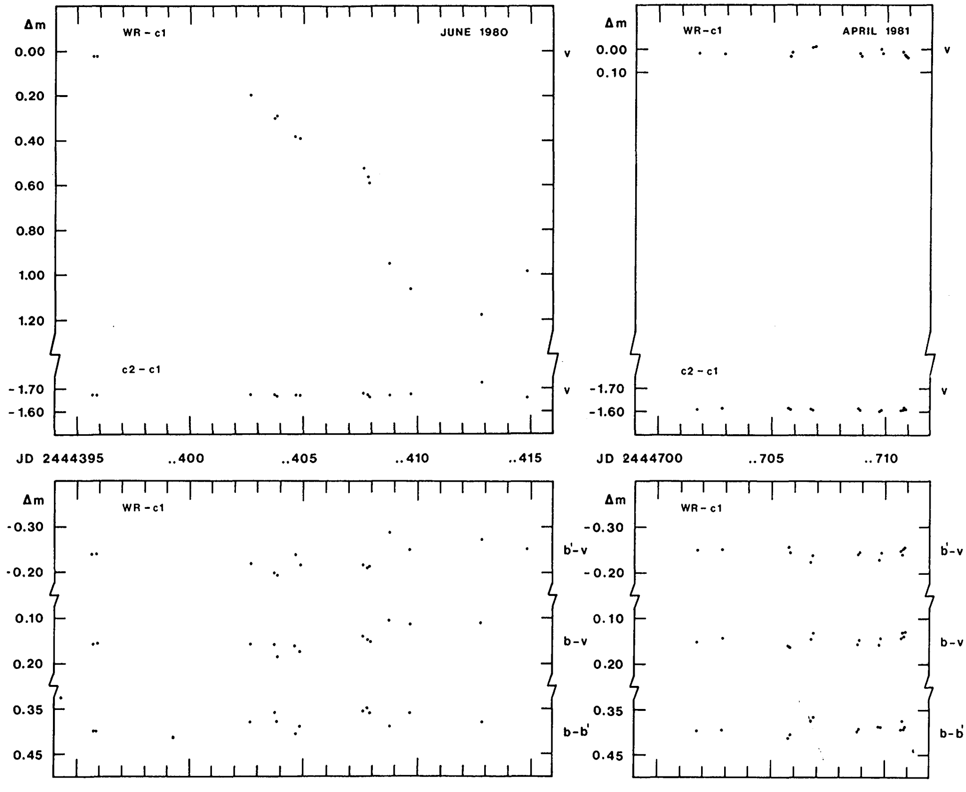

Figure 2. Observations of WR 103 in June 1980 (left) and in April 1981 (right).

As a complement to the photometry we also obtained two spectra of the WR star, both taken in June 1981. One is an objective prism plate giving the 390-500 nm region in moderate dispersion taken with the GPO of ESO. The other is an IDS recording from the ESO 3.6 m telescope displaying the 380-440 nm region in higher dispersion.

3. DISCUSSION

To our knowledge a variation of more than 1^{m} has never before been reported for any WR star. Hjellming and Hiltner (1963) reported once a deep eclipse of about $0\overset{m}{.}6$ for the WR+OB binary CV Ser (= WR 113) but other eclipsing WR systems show eclipses much less than that. The decrease of almost $1\overset{m}{.}2$ in WR 103 must therefore be regarded as outstanding.

Despite the large brightness variation the colour changes are very small. The $(b-v)$ colour became slightly bluer at minimum light. The behaviour of $(b'-v)$ is very similar, while $(b-b')$ does not show any clear long-term variation. The peak-to-peak variation is less than $0\overset{m}{.}1$ for all

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colours. Although the b and v filters were selected to cover regions relatively free from emission lines this cannot be fulfilled for late WC stars, see Figure 1. The contribution from emission lines is about one third of the total flux in b and v, in b' it is half of the total flux. Both the continuum and emission line radiation must then be decreased in order to produce the drop in brightness. The size of the reduction must also be of the same order for emission lines and continuum as no large colour changes are observed. Unfortunately, we do not know how fast the star returned to its normal brightness, but our observations in 1981 are in almost perfect agreement with the first one in 1980. Our spectrograms from 1981 do not show any differences compared with spectra before 1980.

There is no obvious explanation for the June 1980 event. E.g. a sudden formation and subsequent dissipation of an absorbing circumstellar shell is not only physically unlikely, but would also cause large colour changes. An intrinsic fluctuation in the luminosity of this size also seems unlikely, and should also cause considerable colour changes.

Alternatively, we might assume that WR 103 was occulted by a body large enough to cover a large fraction of the star including the emission line region. This body must then be much fainter than the WR star in order to produce the observed Δm remaining undetected spectroscopically. If we assume that a WC9 star has $M_v \approx -5.5$ (Lundström and Stenholm, this symposium) the occulting body can hardly be brighter than $M_v \approx -3$. From our limited observations we can only put some restrictions on the occulting body to explain the light and colour curves. The body must have a semi-transparent outer region. A supergiant may have the necessary properties except that it would be too luminous. A red giant may be large enough and still sufficiently faint. It seems impossible however, that such an old star should orbit a WR star. It is then more promising to assume that the occulting body is a protostar of low mass. With reasonable assumptions regarding masses and radii, the light curve indicates a very long period. The inclination must be close to 90°. The probability of observing such a system is then very low. If WR 103 also has a compact companion, not verified by our data, the system has encountered a supernova stage in the past. It is then unlikely that a protostar in a wide orbit should have remained bound. In view of the limited material available at present it seems premature to pursue the speculations further. We are therefore forced to just add the June 1980 event of WR 103 to the exotic garden of unexplained Wolf-Rayet star phenomena.

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DISCUSSION

Underhill: Could the short-period, small-amplitude variations seen in 1981 be due to the rotation of a spotted star ? It is possible that the star with the WR line spectrum may be an object with an effective temperature near 10000K. I know of one such object. Then perhaps, you might find the idea of a giant G star as a companion plausible.

Stenholm: We have not found any period for the small amplitude variations. The period found by Isserstedt and Moffat is supposed to be due to a compact companion. We cannot confirm their period either.

Smith,L.F.: I observed HD 164270 for 7 consecutive nights and saw slow variation of about 0.1 mag. consistent with a period of 8 or 9 days. Would you have detected this ?

Stenholm: Yes, if your period is real it must be in our data, but then I would like to see the data first.

Moffat: (to Underhill) - If the short period is dure to a hot spot, it might be difficult to explain the double wave light curve and single wave RV curve (P about 1.7 days) of Isserstedt and Moffat.

Hiltner: I am pleased to see that CV Serpentis now has a companion in conspiracy.

Stenholm: So am I !