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Spot modelling in the RS CVn system WY Cnc

P. Vivekananda Rao and M. B. K. Sarma
Centre of Advanced Study in Astronomy, Osmania University, Hyderabad 500 007

RS CVn binaries are a group of stars which exhibit the following properties (Hall 1976):

(i) Orbital period lies in the range of one day to two weeks; (ii) Spectral type of the hotter component is F or G and a luminosity class V or IV; (iii) Presence of strong emission of Ca II H & K; (iv) Distortion wave outside the eclipses.

As suggested by Hall (1972) and now widely accepted, the distortion wave in RS CVn systems is due to starspots located on the surface of one of the components. The eclipsing binary WY Cnc is classified as a member of the RS CVn group as it exhibits many properties common to this group like the H and K emissions and the presence of a distortion wave.

In order to determine the characteristics of the wave in WY Cnc we have observed this system in UBV passbands during the observing seasons 1973-74, 1976-1979 and 1985-86. From our observations we have found the following features:

(i) Presence of a wave-like distortion outside the eclipse; (ii) variation in the depths of the primary minimum; (iii) change in the overall luminosity outside the eclipses; (iv) the hotter component to be responsible for the wave.

In order to determine the shape of the distortion wave and its variation with time we have fitted the observations for each year independently to a Fourier series of the form:

$$l^{obs} = \sum_{n=0}^{2} A_n \cos n\theta + \sum_{n=1}^{2} B_n \sin n\theta, \quad \ldots(1)$$

$$A_1 = A_1\,(\text{ellipticity}) + A_1\,(\text{reflection}) + A_1\,(\text{wave}) \quad \ldots(2)$$

and similarly for A_2.

The elliplicity and reflection terms are determined from the expressions given by Merrill (1970).

We have found that in WY Cnc the primary is a G5 V star and the secondary a K5 V. Using these spectral types and the elements derived from our earlier studies the distortion wave is found for each year of observation using the following equation:

$$l^{wave} = A_0 + A_1(\text{wave}) \cos\theta + A_2(\text{wave}) \cos 2\theta + B_1 \sin\theta + B_2 \sin 2\theta \quad \ldots(3)$$

The distorition waves in all the years showed two distinct minima with a phase difference of about 180°. Since these distortion waves are a manifestation of starspots on the surface of the hotter component, we have used the method of Budding (1977) which assumes circular spots of uniform brightness to model them. For modelling we have used only the V curves. In this modelling procedure there are a large number of free parameters; this makes the solution quite labourious. To reduce the degrees of freedom in the process, we used the limb-darkening (x) and orbital inclination (i) as fixed

parameters. The only adjustable parameters are the longitude (λ), latitude (β), size (γ) and the temperatures of the spots (T_{spot}). These parameters are suitably varied to obtain best fits to the available data. Figure 1 shows the best fit to the observed curve of 1973-74 and the resulting parameters of the modelled curves are given in table 1.

From the derived parameters we infer the following:

(i) Over a time interval of 13 years the three spots (two large and one small) seem to have maintained their indentity. The two large spots are separated by about 180° thereby occupying opposite hemispheres, whereas the smaller spot is in between them.

(ii) From the derived parameters it is not possible to come to any definite conclusion

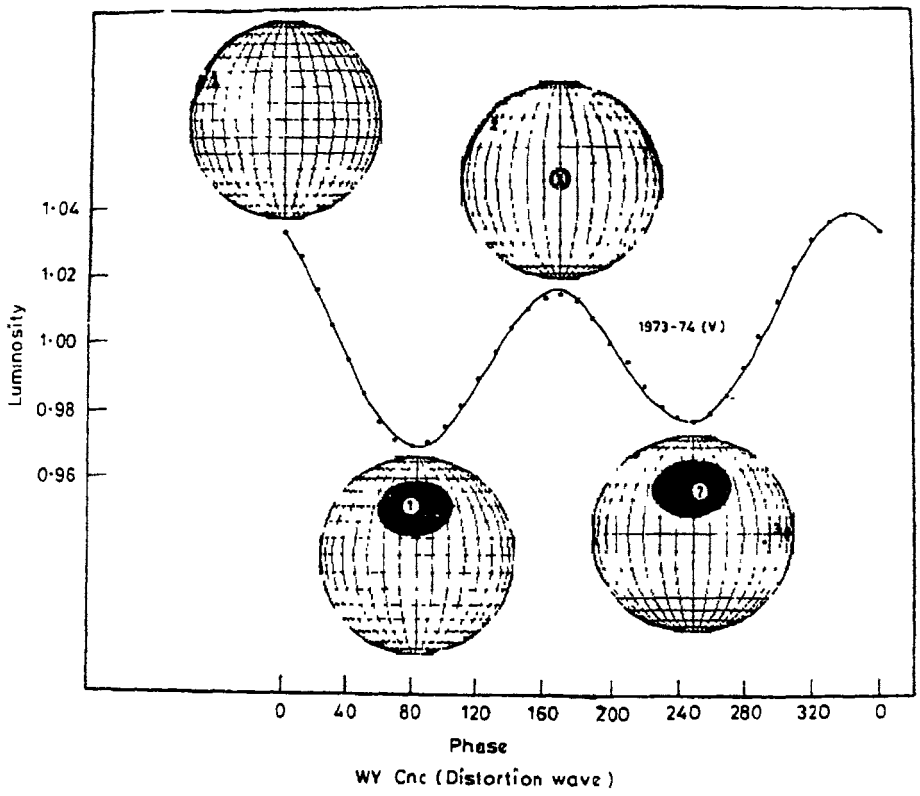

Figure 1.

Table 1. Spot parameters in WY Cnc

Year	Spot 1				Spot 2				Spot 3			
	λ	β	γ	T_{spot}	λ	β	γ	T_{spot}	λ	β	γ	T_{spot}
1973-74	83	28	24	4900 K	247	30	23	4900 K	160	0	08	4900 K
1976-77	115	30	15	4900 K	277	30	20	4900 K	190	0	04	4900 K
1977-78	71	30	21	4950 K	281	30	25	4950 K	0	0	10	4950 K
1978-79	101	25	18	5000 K	261	24	15.5	5000 K	175	2	9.5	5000 K
1985-86	81	28	20	5000 K	242	25	24	5000 K	160	0	6.5	5000 K

regarding the movements (in longitude and latitude), changes in sizes and temperatures of the spots. they seems to be relatively stable.

(iii) The overall brightness of this system is variable. This is explained by means of general spottedness; perhaps a spotted belt all around the star's surface might be responsible for this phenomena.

(iv) The degree of spottedness in this system is found to be in the range 9-15% which is of the same order found in other members of this group like HR 1099 (Dorren *et al.* 1981), HK Lac (Olah *et al.* 1985), *etc.*

A detailed version of this paper will be published elsewhere.

References

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Discussion

Mekkaden : Since WY Cnc is not a very active RS CVn system, a 13-year cycle for the spots seems to be unrealistic.

Vivekananda Rao : Since the light curves change from season to season, the 13-year cycle does not seem to be unrealistic.

Kaul : How can spots be uniformly bright?

Vivekananda Rao : This is an assumption. If we take nonuniform brightness for these spots, the number of free parameters will increase further which makes the solutions even more laborious.

Abhyankar : Did you find any migration of spots in this star?

Vivekananda Rao : No. The spots seems to be relatively stable.