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The Light and Colour Variations of MM Her

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Abstract

RS CVn type eclipsing binary MM Herculis have been observed using B, V, R filters in 1997 and obtained light and colour curves were examined together with the earlier 12 light and colour curves obtained between 1976 and 1997. It was seen that the system is bluer, while it is fainter. Such finding probably reveals the evolutionary effect of the photospheric bright facular structures surrounding starspots.

1. Introduction

The light variations of the RS CVn type eclipsing binary MM Herculis have been investigated by Oliver [1], Hall [2], Popper [3], Sowell et al. [4] and Evren [5-7]. The system has also been studied spectroscopically by Imbert [8]. In this work, the variations in the light curve (V filter) and colour curve ($B - V, V - R$) are presented and a comparison with the previous observations is given.

2. Observations

MM Herculis has been observed with the 48 cm Cassagrain telescope of the Ege University Observatory between July 16 - September 22, 1997, in the B, V, R filters. 94 observations were derived in each filter. The photometer SSP-5A containing a side on Hamamatsu R4457 PMT were used during the observations. The observations were corrected for the atmospheric extinction and transformed to the standard system. The light elements given by Evren [5] as;

$$\text{Min I} = \text{JD Hel. } 2445\ 551.4336 + 7^d.960358\ \text{E}$$

were used in phasing the light and colour curves.

The mean light and colour curves of MM Her for 1997 have been given in Figures 1, 2a and 2b. The eclipses have not been considered in the figures. As can be seen in

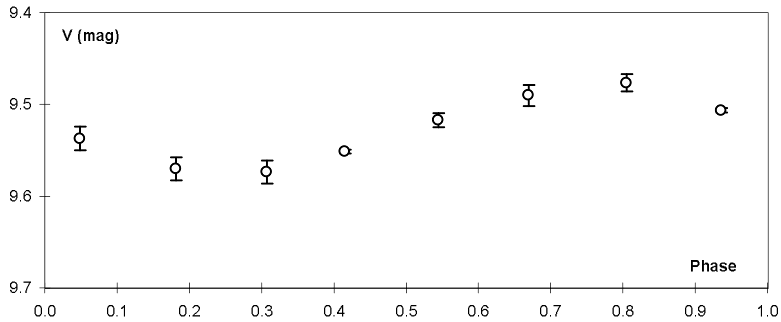

Figure 1. The mean light curve of MM Her for 1997

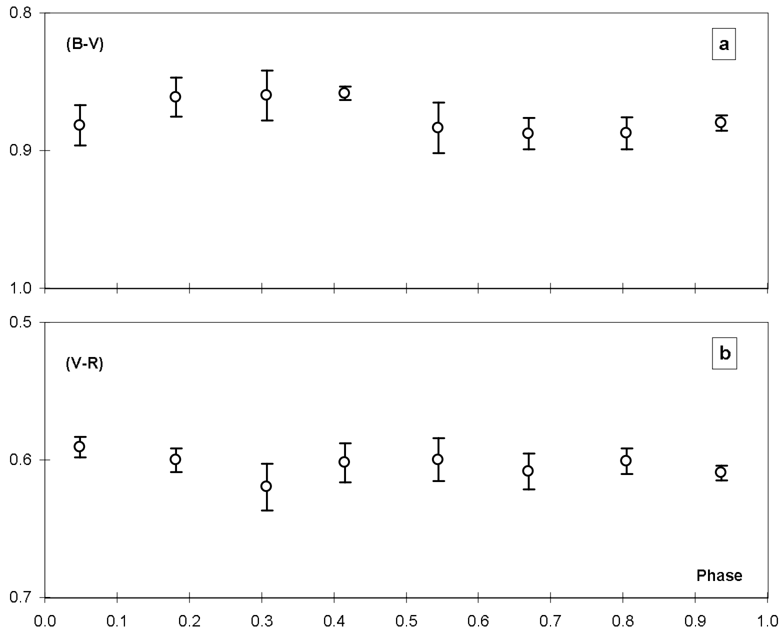

Figure 2. The mean colour curves of MM Her for 1997 (a: $B-V$, b: $V-R$)

Table 1. The photometric parameters for MM Her

Data Set	Mean Epoch	Mean (V mag)	Minimum (mag)	Amp. (mag)	Mean (B-V)	Spot 1	Spot 2	Difference of phase
set A	1976.49	9.531 ±.015	9.562	0.052	0.899 ±.002	0.00	0.45	0.45
set B	1976.67	9.533 ±.030	9.572	0.074	0.890 ±.013	0.82	0.33	0.49
set D	1977.45	9.519 ±.042	9.589	0.130	0.866 ±.015	0.72	0.05	0.33
set F	1977.58	9.540 ±.046	9.612	0.127	0.875 ±.008	0.72	0.04	0.32
set G	1978.40	9.522 ±.040	9.567	0.108	0.880 ±.008	0.68	-	-
set H	1979.64	9.515 ±.030	9.563	0.093	0.880 ±.008	0.46	0.78	0.32
set J	1980.24	9.510 ±.039	9.572	0.112	0.884 ±.011	0.32	-	-
set K	1980.61	9.508 ±.027	9.560	0.080	0.881 ±.011	0.26	0.70	0.44
Evren (1986)	1983.54	9.537 ±.042	9.600	0.135	0.849 ±.015	0.74	0.20	0.46
Evren (1986)	1984.52	9.537 ±.048	9.615	0.153	0.848 ±.009	0.56	0.92	0.36
Evren (1986)	1985.56	9.541 ±.055	9.623	0.158	0.847 ±.012	0.41	0.77	0.36
This Study	1997.62	9.528 ±.035	9.578	0.100	0.875 ±.012	0.26	-	-

(Set A-K): IAU Comm.27 Data File Number 110

Fig. 1, the V observations show very clearly a sinusoidal wavelike distortion. The light minimum is occurred at phase 0.26 while the light maximum is seen at phase 0.80. The amplitude of the light curve is $0^m.1$. The $B-V$ colour curve gets bluer during the light minimum while the $V-R$ colour curve gets redder at the same phase. The amplitudes of the $B-V$ and $V-R$ colour curves are $0^m.03$ and $0^m.02$, respectively. The amplitudes of the light and colour curves are in good agreement with the ones proposed by Henry et al. [9] for the K0 IV stars. If the mean brightness changes entirely as a result of changes in surface brightness rather than changes in stellar radius, amplitudes in $B-V$ should be only about one-fourth as large as the amplitudes in V.

3. Photometric Variations

The observations of MM Her made between 1976-1980 were taken from Sowell et al. [4], and those between 1983-1985 were taken from Evren [10]. Thus, a total of 12 light and colour curves were collected. The photometric parameters obtained from these curves are given in Table 1. When these curves are investigated, some variations similar to those we obtained in 1997 are seen. During the phases of light minima the colours of the system $(B-V)$ gets bluer by $0^m.02-0^m.04$. For instance, this situation is more pronounced in

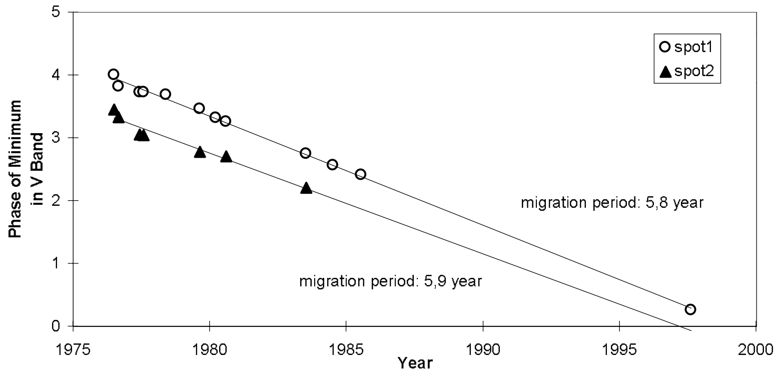

Figure 3. The migration curves of MM Her for Spot1 and Spot2

the observations obtained in 1983, 1984 and 1985.

Except for the three light curves, in all other curves the effects of the two spots or spot groupings are seen. Among these the one which produces more light loss is called the first spot. Other light losses are due to the second spot. The shift of the phases versus years which the two spots are seen is given in Fig. 3. Linear fits indicate a 5.8 and 5.9 years of migration periods for the first and the second spots, respectively. In previous works nothing mentioned about the second spot and the 7.5 years migration period was given for the first spot by Sowell et al. [4]. Evren [6] gave 3.57 years period for the same spot. The motions of the spots or spot groups located on different longitudes were investigated and it was seen that these spots get closer by 0.3 phase between 1978.5 and 1985. The spot groups are separated by 0.5 phase (maximum) from each other between 1976 and 1982. This phase differences between the spot groupings located at different longitudes are plotted against time and presented in Fig. 4. The period of quasi-sinusoidal variation is roughly 6 years and this is equal to the migration period. According to Henry et al. [9], two spot groups separated by 180° from each other. This was based on observational proofs for the chromospherically active stars.

This situation is accepted as the indicators of the long-lived, active rigid longitudes. When the spot groups come closer to each other (Active Region Mutual Approach-ARMA), the shape variations in the light curves were investigated and this investigation reveals some very important results.

In those years when the spot groups get nearer to each other, the amplitudes of the light curves increase (Fig. 5). Between 1977-1978 and 1985 the amplitude reaches to its maximum ($0^m.14$ and $0^m.16$). For the year 1982 it is about $0^m.06$.

When these active regions get closer to each other, the mean brightness of the system varies (Fig. 6). The system is faintest between 1977-1978 and in 1985, and brightest in 1982. Therefore, when the spot groups are close to each other it seems that the activity of the system increases and, so, it seems faintest. If the mean colours of the system is considered for the same years (Fig. 7), an opposite behavior can be seen unexpectedly.

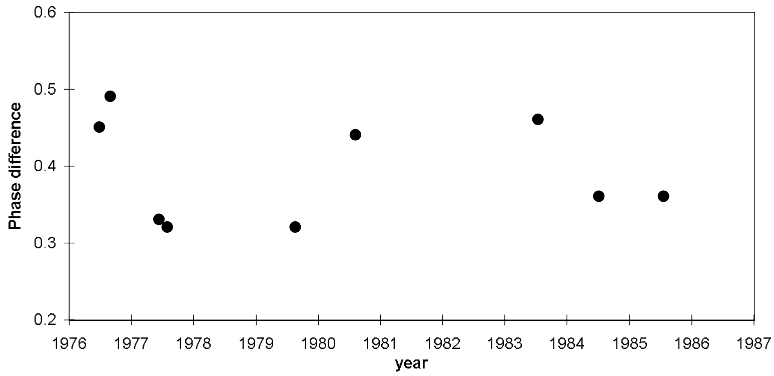

Figure 4. Time dependent variation of the phase differences between two spot groups

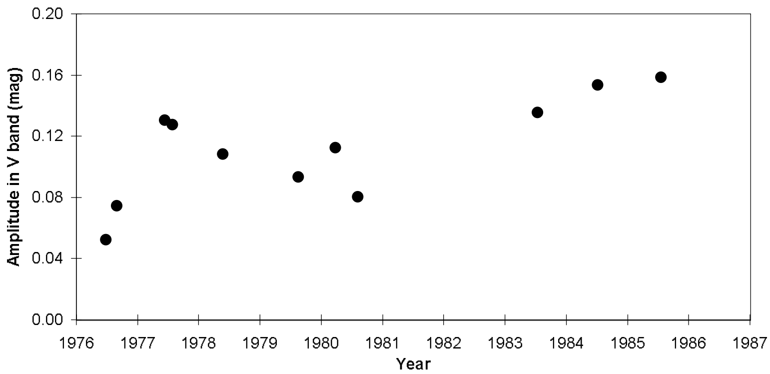

Figure 5. Time dependent amplitude variation of MM Her between years 1976-1985 in V band

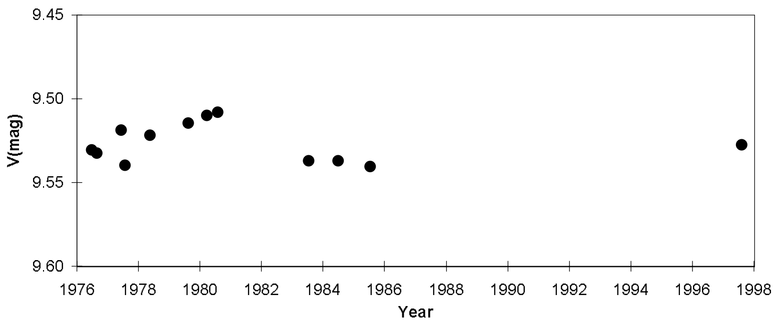

Figure 6. Time dependent variation of the mean brightness of MM Her in V band

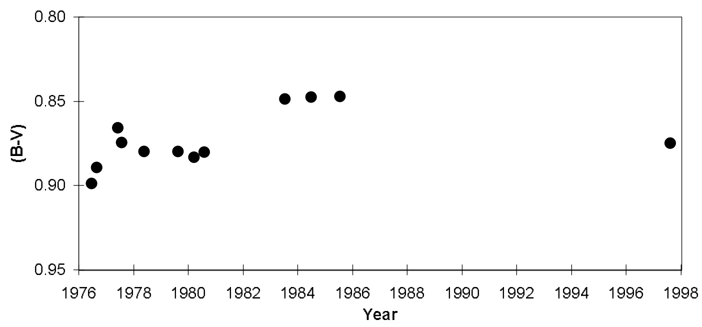

Figure 7. Time dependent variation of the mean colour of MM Her

When the spot groups get closer, the colour of the system gets bluer. The system is bluest when it is faintest, and redder when it is brightest. This can be understood by facular structure which is hotter than the photosphere, surrounds the spots.

As seen in the case of the Sun, the faculae are more prominent in $B-V$ colour. In the study of chromospheric activity effect on the mean colours of late type stars, some suggestions were made by Amado and Byrne [11] on the origin of the UV excess in active stars. The processes that produce the UV excess are: flare, chromospheric emission, X-ray back-heating and faculae.

The bluer effect originating from faculae will be more enhanced for stars with lower effective temperature for which the contrast between the faculae and the photosphere will be larger. The network structure between the ARMA and these regions is more prominent. Similar results were obtained in the study on V711 Tau by Dorren and Guinan [12]. When the mean brightness of V711 Tau diminishes in V colours, its colour gets bluer. The contribution of the active region faculae and the facular network on the Sun's radiation shown by Foukal and Lean [13, 14] makes it easier to explain the observed light and colour variation in active stars. The Sun's luminosity variation is controlled mostly by faculae which are bright photospheric features.

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