

PHOTOMETRIC VARIABILITY FOR THE VV CEPHEI-LIKE STAR HR 8164

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ABSTRACT

HR 8164 (HD 203338/9 = ADS 14864), a VV Cephei-like star, has been found to be photometrically variable over a range of ~ 0.2 V magnitude and a cycle time of several years. This variation is likely of an irregular type and does not seem to be accompanied by a color change.

Key words: M supergiant–visual binary–VV Cep star–emission-line star–photometry

1. Introduction

HR 8164 (HD 203338/9 = ADS 14864 = Boss 5481A) has been called the least peculiar of the VV Cephei stars (Keenan 1970). Though no eclipse has been observed, the spectrum of the star shows the hallmarks of these stars: It is a late-type supergiant binary with an early secondary and occasional emission lines of H, [Fe II], [S II], and [Ni II]. There are possibly four stars in the system. The primary M supergiant has a spectroscopic B-star secondary and a B2.5–3 V (Bidelman 1958; Cowley & Cowley 1966) visual binary companion (separation = 4".5) which may also be a spectroscopic binary (van de Kamp 1962). Spectral types for the composite system have been published as M1ep Ib + B (Bidelman 1958), M1ep Ib + B1: V: (Simonson 1968), and M1.3 Ib + B1.8 V (Wawrukiewicz & Lee 1974).

HR 8164 underwent a curious shell incident in 1965–67 as reported by Cowley & Cowley 1966. At first thought to be evidence of a photospheric eclipse similar to that of VV Cep, the spectrum of the star developed shell lines of Cr II, Ti II, Mn II, and Ni II as well as red-displaced cores to the H lines, and later, emission at H α . Mammano & Martini 1969 who also observed the incident concluded that this episode probably had its origin in the slow passage of the B star behind the extended atmosphere of the M star at a considerable distance from its photosphere. Cowley 1969 suggested the period of the system to be at least 75 years, but this was considered not likely by Mammano and Martini since they found that the radial velocities of the B star were not consistent with that period. Since Adams, Joy & Humason 1925 noted that the hydrogen lines were in faint double emission at one time previously in 1925, a possible period for the system could be ~ 40 years. Speckle interferometry has made it

possible to measure the separations and position angles of what is likely to be the VV Cephei-like pair. Worley 1990 catalogs seven observations, to which may be added three more by McAlister & Hartkopf 1988, resulting in a mean position angle of 120°3 ($\pm 3^\circ 1$) and separation 0".095 ($\pm 0".004$) over the time period 1981–87. No orbital motion would seem to be indicated, suggesting that the longer period is the more likely. Buss & Snow 1988 observed the system twice in June 1988 with the IUE and found that the hot secondary star had a UV spectral type of dB2. Considering the period of 75 years most likely, they suggested that the two stars have evolved independently. HR 8164 is a known radio source with a spectrum similar to that of an H II region making the optically thick to thin transition between 1.4 and 10 GHz (Hjellming 1985). No previous light variations have been found for this star, though Cowley 1969 points out that it has not been well studied. Later, Piccirillo 1974 stated that it is non-variable.

2. The Observations

HR 8164 was added to the photometric monitoring program of the Corralitos Observatory. The system includes a 0.6-m telescope and uncooled EMI 9924A pulse-counting photometer. Seventy-seven nightly observations over seven observing seasons in B and V colors were made via differential photometry from two standard stars: HR 8150 ($V = 5.98$; $(B - V) = +1.45$; K3 III) and HR 8179 ($V = 6.11$; $(B - V) = +1.00$; G5 III). Magnitudes, colors, and spectral types for these stars were taken from *The Bright Star Catalogue*. The average standard errors observed in V and $(B - V)$ for the standard stars were 0.018 and 0.017 magnitude, respectively.

The magnitudes for HR 8164 appear graphically in Figure 1 and are tabulated in Table 1. They were obtained by simple arithmetical mean from differential measures from the standard stars. It may be seen from the figure that HR 8164 undergoes two types of variations. Long-term variation is shown by the brightening of the star in V

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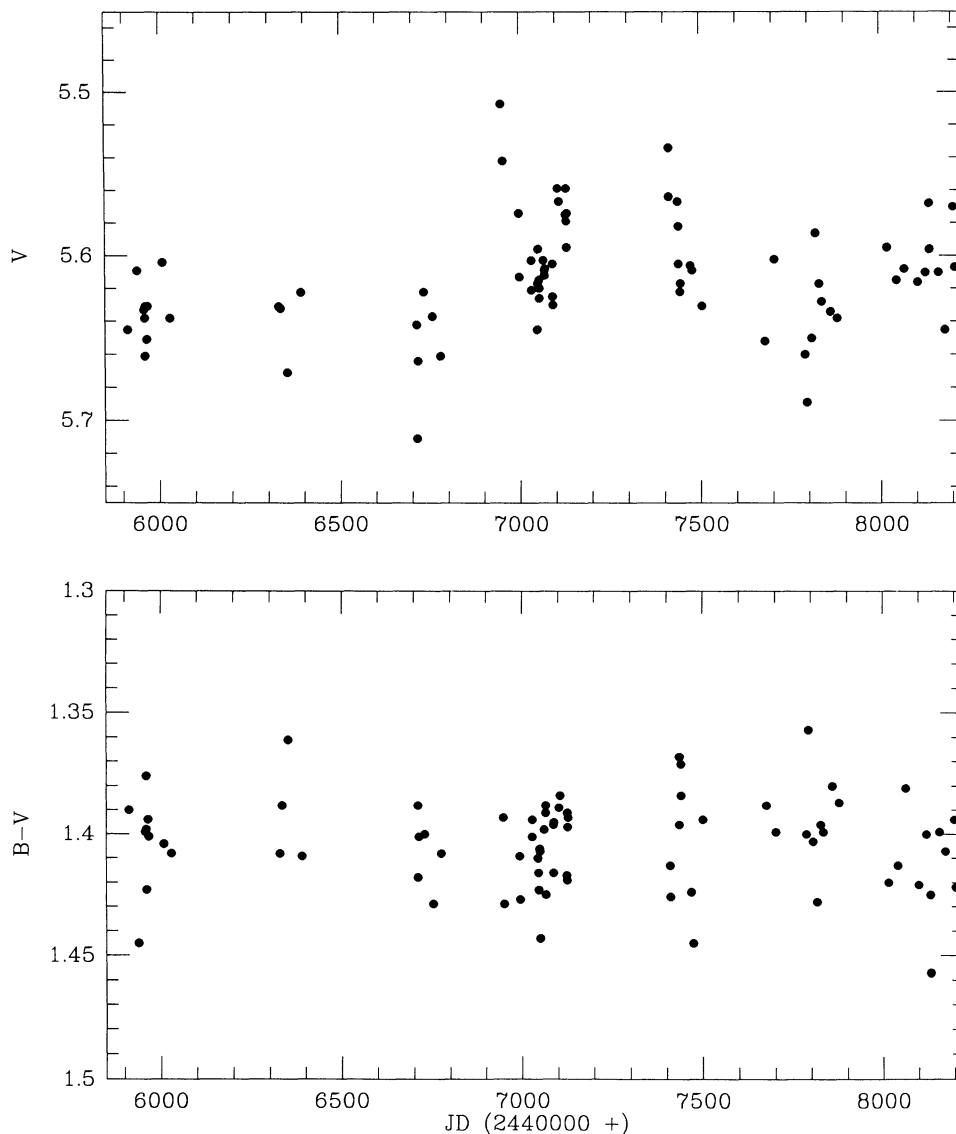


FIG. 1—Magnitudes and colors for HR 8164.

during the 4th and 5th observing seasons. The considerable scatter within each observing season is real and undoubtedly proceeds from minor instabilities or atmospheric clumping of the M supergiant. The brightening on JD2446948-51 is also real: Standard errors about the mean for those nights were ≤ 0.005 magnitude. There seems to be no consistent trend toward $(B - V)$ variation. A $V, (B - V)$ diagram shows no correlation between these quantities.

The type of variability is uncertain due to the insufficiency of the time base when compared with the cycle time of the variations. It is most likely to be an LC-type variable: an irregular variable supergiant of late spectral type with an amplitude < 1 V magnitude. Adams et al. 1925, however, pointed out the similarity of the spectrum to that of W Cephei which is an SRc variable. Merchant 1967 found it similar to HR 2902 (= KQ Puppis), also an

LC variable. Cowley 1969 commented that probably all VV Cephei-like stars are variable by a few tenths of a magnitude outside of eclipse and that they may be “quasi-regular” variables of small amplitude with periods that exist for a few years, only to be damped out and followed later by different values. Stothers & Leung 1971 present cycle times for variable M2 Ib supergiants of 165 days for primary periods and 2050 for secondary. The second of these is consistent with the long-term variations exhibited by HR 8164. Period search techniques (Stellingwerf 1978) showed no periodicities whatsoever in the range 10–1105 days.

A single spectrum centered on $H\alpha$ was obtained on JD2447119.6257 with the coude feed telescope of the Kitt Peak Observatory and its RCA2 CCD (resolution 0.89 \AA per 2 pixel linewidth). Though not shown here, the spectrum was not unusual in any way, showing no emission

TABLE 1

MAGNITUDES FOR HR 8164

(JD=2440000+; SE in thousandths)

JD	V/SE	B-V/SE	JD	V/SE	B-V/SE
5911.8385	5.645(13)	+1.390(14)	7102.6535	5.559(20)	+1.389(10)
5939.7580	5.609(0)	1.445(11)	7106.6618	5.567(16)	1.384(20)
5957.7316	5.633(14)	1.399(16)	7124.6083	5.575(13)	1.417(16)
5959.7653	5.661(9)	1.376(7)	7125.6285	5.579(9)	1.391(0)
5960.7288	5.638(18)	1.398(1)	7126.6118	5.559(5)	1.419(13)
5961.7708	5.631(12)	1.423(7)	7127.6049	5.595(3)	1.397(6)
5964.6740	5.651(7)	1.394(23)	7128.5882	5.574(11)	1.393(4)
5967.6573	5.631(4)	1.401(13)	7411.7861	5.564(3)	1.413(6)
6009.5910	5.604(5)	1.404(4)	7412.7306	5.534(0)	1.426(19)
6029.5806	5.638(16)	1.408(19)	7435.7542	5.567(45)	1.368(1)
6329.7354	5.631(16)	1.408(16)	7436.7118	5.582(0)	1.396(0)
6334.6229	5.632(6)	1.388(4)	7437.6896	5.605(11)	1.368(25)
6351.6645	5.671(11)	1.361(11)	7440.6743	5.622(17)	1.371(1)
6391.5993	5.622(13)	1.409(3)	7441.6847	5.617(0)	1.384(15)
6710.6444	5.642(0)	1.388(1)	7470.6375	5.606(0)	1.424(0)
6711.7513	5.711(0)	1.418(0)	7475.6090	5.609(0)	1.445(10)
6714.7493	5.664(16)	1.401(4)	7502.5715	5.631(12)	1.394(4)
6730.7284	5.622(0)	1.400(0)	7676.8951	5.652(5)	1.388(14)
6754.5784	5.637(0)	1.429(21)	7703.8757	5.602(4)	1.399(10)
6776.5701	5.661(17)	1.408(0)	7788.7389	5.660(3)	1.400(16)
6948.8736	5.507(5)	1.393(18)	7793.7653	5.689(0)	1.357(11)
6951.9132	5.542(1)	1.429(9)	7806.6542	5.650(6)	1.403(23)
6994.8208	5.574(8)	1.409(8)	7818.6979	5.586(11)	1.428(11)
6995.7757	5.613(14)	1.427(0)	7827.7028	5.617(0)	1.396(12)
7028.7673	5.603(0)	1.401(13)	7835.6750	5.628(18)	1.399(9)
7029.6930	5.621(2)	1.394(2)	7859.6049	5.634(12)	1.380(13)
7045.7534	5.645(14)	1.410(10)	7878.5708	5.638(19)	1.387(24)
7046.7548	5.617(21)	1.416(3)	8015.9431	5.595(3)	1.420(12)
7047.7819	5.596(13)	1.423(6)	8041.9174	5.615(5)	1.413(13)
7049.7458	5.615(4)	1.406(9)	8064.8326	5.608(24)	1.381(18)
7050.8375	5.620(10)	1.407(2)	8100.7500	5.616(7)	1.421(12)
7051.6958	5.626(16)	1.443(4)	8122.7229	5.610(6)	1.400(19)
7062.6951	5.603(10)	1.398(6)	8133.7521	5.596(0)	1.425(0)
7065.7431	5.612(0)	1.388(0)	8134.6535	5.568(3)	1.457(3)
7066.7097	5.609(5)	1.391(6)	8159.6847	5.610(10)	1.399(4)
7067.6819	5.608(18)	1.425(1)	8176.6493	5.645(33)	1.407(34)
7087.6549	5.605(0)	1.416(1)	8201.6076	5.570(35)	1.394(18)
7088.7104	5.625(18)	1.396(15)	8204.5917	5.607(1)	1.422(1)
7089.6222	5.630(5)	1.395(1)			

nor shell components at H α . A radial-velocity measure for the H α absorption line gave a value of $-10 (\pm 3) \text{ km s}^{-1}$, consistent with the value of -21 SB given in *The Bright Star Catalogue*. Therefore, it may be stated that the spectrum of the M star in the H α region showed no outstanding peculiarities during the critical 4th observing season when the system began to brighten.

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