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Spectrophotometric observations of B type stars HR 1207 and HR 1770

S. C. Joshi and D. K. Ojha
Uttar Pradesh State Observatory, Manora Peak, Naini Tal 263 129

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Abstract. Two high rotational velocity B type stars HR 1207 and HR 1770 have been observed spectrophotometrically. The energy distribution curves of the stars have been compared with model atmospheres in the ultraviolet and visible regions. Temperature estimates with diffentent methods are made and certain peculiarities in the energy distribution curves of the stars discussed.

Key words : B stars—Be stars—energy distribution

1. Introduction

HR 1207 and HR 1770 (23 Ori) are B type stars of luminosity class V having high rotational velocities. Their $v \sin i$ values of 286 km s^{-1} and 295 km s^{-1} (Hoffleit & Jaschek 1982) respectively are on the higher side of the mean $v \sin i$ values for Be stars, which range between 200 to 250 km s^{-1} for Be stars of luminosity classes III, IV and V (Slettebak 1982). HR 1207 It belongs to Per OB3 group and has the spectral type B6V. HR 1770 belonging to Ori OB1 association has been assigned a specitral type B1V.

It is well known that rapid rotation in B type stars plays a crucial role in the overall Be phenomenon in the sense that all Be stars are rapid rotators, yet rotation may not be directly responsible for triggering the Be phenomenon. A star of given rotational velocity can alternately display B-Be-Be shell characteristic at different times. Hoffleit & Jasckek (1982) have remarked that HR 1770 could become Be star. HR 1207 has $v \sin i$ value comparable to that of HR 1770 but has a later spectral type.

In order to see the behaviour of the energy distribution curves of HR 1207 and HR 1770 in relation to other stars and model atmospheres for normal stars of appropriate. temperature and effective gravity range we have observed these stars spectrophotometrically.

2. Observations

The stars were observed on 1988 December 7 with the 104-cm reflector of Uttar Pradesh Observatory, Naini Tal. The spectrum scanner used for these observations has a dispersion of 70 Å mm^{-1} at the exit slit. Thermoelectrically cooled EMI 9658B photomultiplier and d.c. recording technique have been used. The exit slit was set at 0.7 mm admitting about 50 Å of the spectrum. Data were obtained in a continuous scanning mode.

The standard star γ Gem was observed on the night along with the program stars to enable conversion of the observed energy distribution into absolute units. The mean extinction coefficients collected for the observatory site pertaining to the observing season October-December were applied to the observations to correct them for atmospheric extinctions. The extincion corrected magnitudes of HR 1207 and HR 1770 have been converted into absolute values using the standard magnitudes of γ Gem given by Taylor (1984). The monochromatic magnitudes of the program stars have been corrected for intersteller reddening.

Interstellar reddening corrections for the stars have been determined using the Q method (Johnson & Morgan 1953) which is valid for the main sequence OB stars. In particular we have used the intrinsic colours corresponding to the spectral types of the stars as given by Golay (1974).

Additionally we have determined the interstellar reddening for the stars using the method given by Beeckmans & Hubert-Delplace (1980) based upon the strength of interstellar absorption feature at λ 2200 Å. For this, the ultraviolet fluxes of the stars from the catalogues of Jamar *et al.* (1976) and Macau-Hercot *et al.* (1978) have been used.

The mean values of $E(B-V)$ as determined with the help of the two approaches have been used to correct the observed mangitudes of the program star for interstellar reddening. The mean values of the reddening from the two approaches come out to be $0^m.07$ and $0^m.10$ for HR 1207 and HR 1770 respectively. Absorption at different wavelengths $A(\lambda)$ have been determined with the help of the interstellar reddening curve given by Nandy *et al.* (1975). The reddening corrected monochromatic magnitudes of the stars have been given in table 1 and are displayed in figure 1.

3. Discussion and results

(a) *Temperature estimation* : The Paschen slopes of the energy distribution curves of HR 1207 and HR 1770 have been determined between $\lambda^{-1} = 1.82$ and 2.5 μm^{-1}. The Paschen slopes of the model atmosphere fluxes taken from Kurucz (1979) were also determined identically. A plot of the model atmosphere slopes against effective temperatures of the models was made for log $g = 3.5$, 4.0 and 4.5. Assuming log $g = 4.0$ corresponding to luminosity class V of the program stars, their temperatures were estimated with the help of observed Paschen slopes. For comparison we have taken spectrophotometric data of two stars HR 4119 (B6V) and HR 8651 (B1V) from the catalogue of Breger (1976) and have carried out similar analysis using $E(B-V) = 0^m.00$ and $0^m.16$ for the two stars respectively.

(b) *Temperature estimates from the Balmer jump* : For normal early type stars the Balmer jump (BJ) is an indicator of the effective temperature of the stars. This parameter has the advantage that it is least affected by the reddening correction. In case of Be stars also, the stellar component of the BJ bears a correlation with the effective temperature. In case of Be stars where Balmer continuum is in emission the observed Balmer discontinuity in low resolution scans is smaller than the stellar Balmer continuity. High

Table 1. Mean dereddened monochromatic magnitudes (normalised at $1/\lambda = 1.82$) of stars

HR 1207 (B6V)			HR 1770 (B1V)	HR 4119 (B6V)			HR 8651 (B1V)		
λ (Å)	1/λ (μm^{-1})	mag.	mag.	λ (Å)	1/λ (μm^{-1})	mag.	λ (Å)	1/λ (μm^{-1})	mag.
3400	2.94	0.071	−0.303	3300	3.03	0.164	3400	2.94	−0.437
3500	2.86	0.082	−0.298	3350	2.99	0.140	3450	2.90	−0.407
3600	2.78	0.161	−0.150	3400	2.94	0.155	3500	2.86	−0.392
3700	2.70	0.182	−0.060	3450	2.90	0.165	3560	2.81	−0.369
3800	2.63	−0.090	−0.093	3500	2.86	0.159	3615	2.77	−0.347
3900	2.56	−0.461	−0.452	3550	2.82	0.185	3670	2.72	−0.323
4000	2.50	−0.565	−0.554	3570	2.80	0.186	4050	2.47	−0.505
4100	2.44	−0.499	−0.498	3636	2.75	0.189	4170	2.40	−0.466
4200	2.38	−0.429	−0.454	4032	2.48	0.456	4230	2.36	−0.441
4300	2.33	−0.387	−0.430	4167	2.40	0.532	4300	2.33	−0.441
4400	2.27	−0.366	−0.403	4255	2.35	0.399	4400	2.25	−0.365
4500	2.22	−0.328	−0.362	4466	2.24	0.341	4510	2.22	−0.340
4600	2.18	−0.296	−0.316	4566	2.19	0.371	4580	2.18	−0.300
4700	2.13	−0.269	−0.287	4780	2.09	0.257	4615	2.17	−0.280
4800	2.08	−0.239	−0.245	5000	2.00	0.168	4680	2.14	−0.250
4900	2.04	−0.185	−0.177	5263	1.90	0.074	4785	2.09	−0.215
5000	2.00	−0.147	−0.142	5500	1.82	0.000	5000	2.00	−0.108
5100	1.96	−0.114	−0.105	5556	1.80	0.017	5260	1.90	−0.053
5200	1.92	−0.079	−0.072	5840	1.71	0.012	5500	1.82	0.000
5300	1.89	−0.055	−0.044	6056	1.65	0.084	5560	1.80	0.034
5400	1.85	−0.026	−0.021	6436	1.55	0.175	5840	1.71	0.132
5500	1.82	0.000	0.000				6050	1.65	0.222
5600	1.79	0.030	0.037				6370	1.57	0.332
5700	1.75	0.063	0.074						
5800	1.72	0.104	0.116						
5900	1.69	0.121	0.169						
6000	1.67	0.148	0.218						
6100	1.64	0.153	0.240						
6200	1.61	0.158	0.236						
6300	1.59	—	0.211						

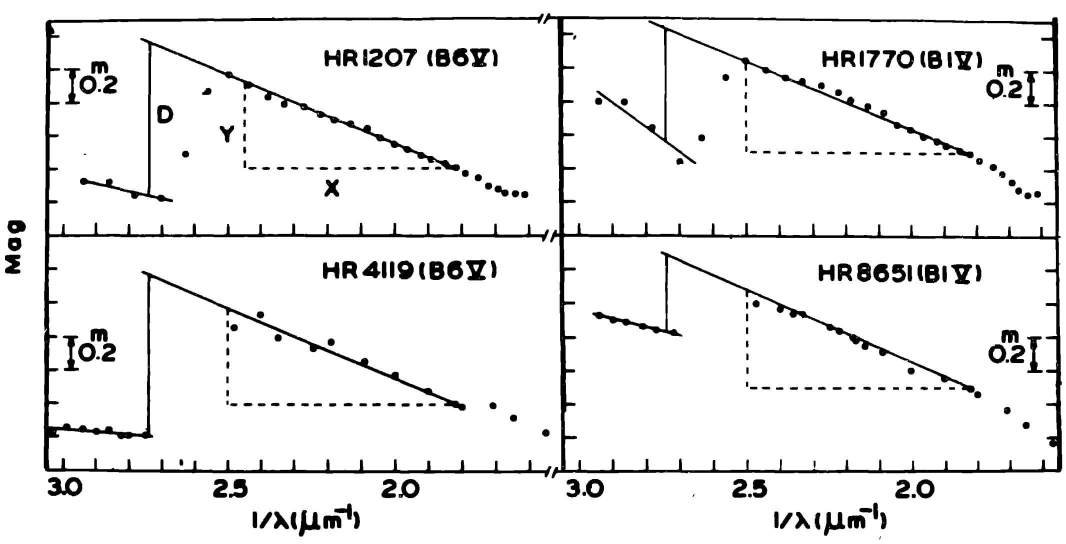

Figure 1. Plot of reddening free magnitudes (normalised at $1/\lambda = 1.82\ \mu m^{-1}$) of HR 1207, HR 1770, HR 4119 and HR 8651 against $1/\lambda$.

resolution scans of Be stars show a second Balmer discontinuity caused by the circumstellar envelope around the star. Our spectral scans being of low resolution cannot show the second Balmer discontinuity even if it exists. We have, however, determined the height of the Balmer jump, D, by joining the fluxes plotted as normalised monochromatic magnitudes shortward of $\lambda^{-1} = 2.74$ μm^{-1} with best fit line and extrapolating the longward fluxes in accordance with the Paschen slope to $\lambda^{-1} = 2.74$ μm^{-1}. Similar treatment was applied to the model atmosphere fluxes from Kurucz (1979) to determine theoretical values of the Balmer jump, for different values of model effective tempertures. D versus effective temperature plot was constructed for the model atmospheres, from which the temperatures of the program stars were estimated assuming again $\log g = 4.0$.

(c) *Temperature from ultraviolet fluxes* : The temperature estimates of all the four stars have also been made using their ultraviolet fluxes in the range $\lambda^{-1} = 7.25$ to 3.65 μm^{-1} taken from Jamar *et al.* (1976) and Macau-Hercot *et al.* (1978). They have also been dereddened and from these a slope parameter comprising of the slopes at three wavelength ranges namely $6 < \lambda^{-1} < 6.6$, $4.8 < \lambda^{-1} < 6.0$ and $4 < \lambda^{-1} < 4.8$ has been formed. Similar slope parameter has been formed from the model atmosphere energy distribution curves for different effective temperatures. Through a comparison of the slopes in a manner as described for the visible region above, the temperatures of the stars have been estimated.

(d) *Temperature from spectral and luminosity types* : From the calibration of effective temperature in terms of the spectral types for different luminosity classes of stars (Schmidt-Kaler 1982) also the effective temperatures of the stars have been determined.

Table 2 lists the various temperature estimates and other parameters of the stars.

HR 1207 : In case of HR 1207, the effective temperature from both the Paschen and Balmer continuum slopes is of the same order, but the temperature determined from the Balmer jump is quite low. The temperature from Balmer jump, however, matches the temperature estimated with the spectral calibration. The observed and empirical Balmer jumps are also equal. The increased slopes of the Balmer and Paschen continua leading to higher values of the effective temperatures could be due to rotational and inclination effects.

HR 1770 : For HR 1770 the temperature estimates from the Paschen and Balmer continua and the spectral type calibration come out to be nearly equal. But the temperature from Balmer jump is quite low. Also the observed Balmer jump is greater than the empirical value. The increased value of the Balmer jump could well be due to additional absorption near the Balmer series limit due to presence of circumstellar material around the star.

HR 4119 : HR 4119 also shows somewhat higher temperatures as determined from the Balmer and Paschen slopes. The temperature given by Balmer jump and the spectral type calibration are equal. The observed BJ is the same as the empirical value. The change in the Paschen and Balmer slopes could in this case also be ascribed to the inclination angle and the rotational velocity.

HR 8651 : For HR 8651, all the temperature estimates match with one another and the observed BJ is nearly equal to the empirical one. For this star the rotational velocity is not known.

Table 2. Temperature estimates and other parameters of the stars

Star	Spectral type	V	$B-V$	$E(B-V)$	$v \sin i$ km s^{-1}	Effective temperature estimates (K)				Balmer jump empirical D (mag)	Observed Balmer jump D (mag)
						From Paschen cont.	From Balmer cont.	From Balmer jump	From spectral calibration		
HR 1207 (HD 24504)	B6V	$5^m.37$[1] $5^m.33$[2]	$-0^m.08$[1] $-0^m.07$[2]	$0^m.07$	286	24,000	20,300	13,350	14,000	0.89	0.93
HR 1770 (HD 35149)	B1V	$5^m.00$[1] $4^m.99$[3]	$-0^m.15$[1] $-0^m.16$[3]	$0^m.10$	295	27,500	28,000	17,000	25,400	0.35	0.67
HR 4119 (HD 90994)	B6V	$5^m.09$[1] $5^m.08$[3]	$-0^m.14$[1,3]	$0^m.00$	114	18,650	19,200	13,100	14,000	0.89	0.96
HR 8651 (HD 215191)	B1V	$6^m.43$[1,2]	$-0^m.09$[1,2]	$0^m.16$	—	25,800	26,000	22,700	25,400	0.35	0.46

[1]Hoffleit & Jaschek (1982).
[2]Jamar *et al.* (1976).
[3]Macau-Hercot *et al.* (1978).

4. Conclusions

For the stars HR 1207 and HR 4119 the difference in the temperature determined from Balmer and Paschen slopes and from the Balmer jump and spectral type calibration can be due to rotation effect. For HR 1770, however, there are indications of increased absorption near the Balmer discontinuity, which is suggestive of the presence of circumstellar matter around the star. For HR 8651 the temperature estimated from diffrent approaches tally, and the Balmer Jump is consistent with the star's spectral and luminosity class.

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