ENERGY DISTRIBUTION OF Be STARS

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1. Introduction

Be stars are defined to be non-supergiant early-type stars of spectral type B showing at times Balmer emission lines in their spectra. These stars often develop strong stellar winds considered to be variable in nature (Slettebak 1988) and have high rotational velocities compared to normal stars of similar spectral types. They also tend to show an excess amount of energy in the near- and far-infrared region compared to normal stars which is presumed to be due the surrounding material around the central star. Thus, the observed energy is a combination of that due to the stellar source and the surrounding material. Various attempts have been made to disentangle the stellar energy component from that of the circumstellar component in order to understand the nature, size and temperature of the envelope. These include:

a) Radius determination based on IR excess (Gehrz et al. 1974, Dachs and Hanuschik 1984; Waters et al. 1987),

b) Radius estimates from polarization and spectrophotometric data (Jones 1979),

c) Envelope dimensions derived from the width of shell absorption cores (Kogure 1969; Hirata and Kogure 1977),

d) Dachs et al. (1992) attempted to understand the physical properties, flow patterns and density distribution of the gas by a comparison of synthetic emission line profiles and empirical profiles measured for real Be stars.

Thus, the estimated disk radii are different for different authors due to the way the optical depth is defined. In this analysis, an attempt is made to estimate the photospheric temperatures, distances, the envelope size and temperature without any recourse to the definition of optical depth from the published energies in various passbands with a simple assumption that both the central star and the surrounding disk or envelope will be radiating like a blackbody and the decrement in the observed radiation strictly follows the inverse square of the distance.

2. Data and reduction

Published broadband magnitudes for 23 selected Be stars have been corrected for interstellar absorption and the corrected magnitudes have been converted into absolute flux units through the calibrations given by Johnson (1966) and in the IRAS Supplementary Catalogue. The observed energy distribution of each star is fitted with a representative blackbody tempera-

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ture by covering maximum number of observed energies. This temperature of the photospheric flux is thus estimated on the basis of visual inspection of the best fit between the observed and the predicted, covering as many passbands as possible while keeping in view the spectral type and luminosity classification of the star. The zero-point shift between the observed and the predicted allows us to estimate the distance to the star. Once we have established the flux emitted by the photosphere of the star in each passband through a blackbody analysis, the difference between the observed and the predicted flux could be attributed to the contribution by the circumstellar material. The distribution of this residual flux with wavelength allows us to estimate the temperature of the material. The relevant shift factor would lead to an estimation of the extension or spread of this material in terms of stellar radii. The parameters thus derived are given in Table I for all 23 stars and compared with other earlier estimates.

3. Results

The present analysis suggest that HD 5394, HD 22192, HD 50013, HD 63462 and HD 148184 have two component shell structure, while, HD 6811, HD 10516, HD 30076, HD 372023, HD 41335, HD 50138, HD 142983 and HD 217891 showed a single component structure. In the case of HD 20336, HD 24534, HD 35439, HD 83953, HD 86612, HD 91120, HD 120324, HD 138749, HD 142926 and HD 217675 no predominant shell structure has been noticed except some slight excess emission at longer wavelengths in spite of that they are classified as Be stars. The present analysis suggests that our estimated shell temperatures are lower than those of Waters et al. (1987). In addition, both Waters et al. and Andrillat et al. (1990) had suggested a predominant shell structure for HD 20336 and HD 35439, while the present analysis could not confirm this. Further investigations are necessary.

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TABLE I

Estimation of derived stellar temperatures and distances, and temperature and radii of the shells

HD	Sp.T.	Temperature (K)				Distance (pc)			Temperature (K)			Radius(R_*)			
		Sp.T.	Pres. An.	DH[a]	KM[a]	M_V	Flux	KM[a]	Sh. 1	Sh. 2	WCL[a]	Sh. 1	Sh. 2	WCL[a]	AJJ[a]
24534	O9.5 V	31500	30600			462	417								
63462	B0 V	30000	29550	30000	28000	402	389		4000	1000		3.96	16.03	>3.0	
5394	B0 IV	29500	30200			245	223		3350	750	25000:	5.69	21.14	>5.6	
35439	B1 V	25400	25850			316	342	490						>3.6	1.31; 3.66
37202	B1 IV	24700	20000			174	183	135	1000		11000	9.77		>4.8	1.01; 1.77
50013	B1.5 V	23700	23700	22500	25000	218	238		10000	400	19000	1.86	54.95	>5.3	
148184	B1.5 V	23700	24000	22500		149	140		3000	300		5.37	47.86	>7.4	
10516	B2 V	22000	23000			108	139	205	1000		16000	15.14		>6.8	
41335	B2 V	22000	22000	22500	21000	239	277		2500			4.17		>4.5	1.66; 3.43
30076	B2 V	22000	22000		20000	378	482		3500			3.63			1.37; 6.00
120324	B2 IV-V	22000	25850	22500		111	185							>1.6	
20336	B2.5 V	20350	20500			214	274	275						>2.4	1.09; 1.72
142983	B3 IV	17800	15000			246	300	230	1250			9.44		>3.0	
86612	B4 V	17000	15000			297	321								
22192	B5 V	15400	20500			104	142	115	3350	750	12000	2.45	18.19	>6.2	1.70; 4.48
83953	B6 V	14000	13500	15500	16600	130	121								
138749	B6 V	14000	13350			99	96								
217891	B6 V	14000	13600		14800	117	111		600			10.23		>2.4	
217675	B6 III	14100	15000			111	153								
6811	B7 V	13000	13000			85	80		700			6.17		>1.8	
50138	B7.5 V	12450	13000			202	224		1100			64.56			
91120	B9 V	10500	10500			114	145								
142926	B9 V	10500	11000			129	120								

[a]See references