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SPECTROPHOTOMETRIC INVESTIGATION OF Be STARS

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Abstract. The continuum energy distribution data of seven Be and five normal B stars have been presented in the wavelength range $\lambda\lambda$3200–8000 Å. Empirical effective temperatures of these stars have been derived by comparing the observed continuum energy distributions with the computed energy distributions given by Kurucz (1979). The effective temperatures of all observed Be stars except KX And found here are in fair agreement with those of normal B stars. The Be stars KY And, EW Lac, and LQ And show normal continuum energy distributions over the whole observed wavelength range. The Be stars ES Vul and 6 Cyg show moderate near-infrared excess emission longward of λ6000 Å. *o* And shows Balmer jump slightly in absorption and 6 Cyg shows slightly in emission. The variable nature of the Be stars has been discussed.

The Be star KX And shows a peculiar type of continuum energy distribution. The continuum energy distribution of KX And has been discussed in relation to its binary nature.

No excess or deficiency in the mean flux of normal B stars was detected.

1. Introduction

Continuum energy distributions in the visible region are very important for deriving effective temperatures of early-type stars since most of their energy is emitted in this wavelength region. A complete understanding of Be phenomena is complicated due to the diversity of objects under study and by the wide range of phenomena exhibited by individual stars. Irregular variations of light, infrared excess, ultraviolet excess, and ultraviolet deficiency, emission line strength, etc., are common features connected for a large number of Be stars. Because of the anomalous colours shown by many Be stars due to excess or less emission shortward of Balmer discontinuity and excess emission in infrared, it is difficult to derive effective temperatures of some of the Be stars.

Be stars display many peculiarities in their continuum energy distributions. Barbier and Chalonge (1941) have found that the Balmer jump is smaller for Be stars than for B stars. Also, they found the colour temperatures of Be stars lower than those of normal B stars. Mendoza (1958) has concluded that the majority of Be stars have an ultraviolet excess. Johnson (1967) has found that Be stars show an excess of infrared flux in comparison with normal B stars. Bottemiller (1972) and Briot (1978) have found no excess or deficiency in the ultraviolet fluxes. A few studies (Schild *et al.*, 1974; and Schild, 1976, 1978) of a large number of Be stars have shown that the Balmer jump is likely to be in emission in Be stars. Delplace and Van der Hucht (1976), Beeckmans (1976), Heap (1976), Schild (1978), and Chkhikvadze (1980) have found deficiency in the ultraviolet fluxes of some Be stars.

The purpose of the present paper is to study the continuum energy distributions of Be stars as compared to those of normal B stars and to discuss their variable nature. No continuum energy distribution data of these stars have yet been published. To

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provide a basis for investigation of continuum energy distributions and to specify the properties of these Be stars – particularly with regard to their continuum energy distributions – we have made spectrophotometric observations of these stars. The observed spectra in the visible region corrected for interstellar reddening are superimposed on the synthetic spectra constructed by Kurucz (1979) for deriving empirical effective temperatures of the stars.

2. Observation and Reduction

The stars studied in this program are listed in Table I. Their spectral types are those adopted from Hubert-Delplace and Hubert (1979) and Hirshfeld and Sinnott (1982). The measured visual monochromatic magnitudes (m_{5500}) of the stars have been given in the fourth column of Table I.

TABLE I

A list of stars observed in this study

HD	Star name	Sp. t.	m_{5500} (m_v)	$E(B-V)$	T_{eff} (K)	log$g$
			Be stars			
180968	ES Vul	B0.5IVe	$5\overset{m}{.}40$	$0\overset{m}{.}16 \pm 0\overset{m}{.}02$	30000	4.0
218674	KY And	B3Vne	6.74	0.11 ± 0.02	22500	4.0
217050	EW Lac	B2IIIe	5.43	0.09 ± 0.02	22500	3.5
224559	LQ And	B4Vne	6.50	0.11 ± 0.02	25000	4.0
217675	*o* And	B6IIIe	3.62	0.01 ± 0.02	14000	3.5
18394	6 Cyg	B9Ve	5.11	0.02 ± 0.02	12000	4.0
218393	KX And	B0IV-IIIe	7.02	0.11 ± 0.02	20000 8000	3.5
			Normal B stars			
214680	10 Lac	O9IV	$6\overset{m}{.}00$	$0\overset{m}{.}11$	30000	4.0
217101	HR 8733	B2IV-V	6.21	0.09	22500	4.0
184171	8 Cyg	B3IV	4.74	0.07	20000	3.5
184606	9 Vul	B7V	5.01	0.02	13000	4.0
217782	2 And	A3V	5.10	0.00	8000	4.0

The stars were observed with the Hilger and Watts scanner at the Cassegrain focus of 104 cm reflector on two nights in 1983, 12 and 13 November. The instrumentation used for taking observations has been described earlier (Goraya, 1984). An exit slot of 50 Å passband was used throughout. Each star was observed four to five times in a night and the continuum was drawn through each scan. Each scan was reduced to instrumental magnitudes separately and all scans of individual star in a night were averaged. The observations of each star were repeated on another night. The standard stars α Lyrae and ξ^2 Cet were observed on each night alongwith the program stars. The mean

TABLE II

De-reddened mean monochromatic magnitudes of Be stars normalised to wavelength λ5500 Å

λ (Å)	$1/\lambda$ (μ^{-1})	ES Vul	KY And	EW Lac	LQ And	o And	6 Cyg	KX And
3200	3.13	$-0\overset{\text{m}}{.}765$	$-0\overset{\text{m}}{.}500$	$-0\overset{\text{m}}{.}540$	$-0\overset{\text{m}}{.}650$	$0\overset{\text{m}}{.}340$	$0\overset{\text{m}}{.}430$	$0\overset{\text{m}}{.}035$
3300	3.03	-0.750	-0.445	-0.490	-0.585	0.375	0.435	0.095
3400	2.94	-0.629	-0.385	-0.415	-0.515	0.388	0.401	0.106
3500	2.86	-0.599	-0.364	-0.365	-0.440	0.398	0.465	0.125
3600	2.78	-0.550	-0.325	-0.335	-0.420	0.345	0.464	0.110
3700	2.70	-0.501	-0.310	-0.340	-0.430	0.165	0.262	0.075
3800	2.63	-0.582	-0.320	-0.432	-0.555	-0.150	-0.095	0.012
3900	2.56	-0.607	-0.435	-0.510	-0.570	-0.370	-0.285	-0.072
4000	2.50	-0.596	-0.490	-0.513	-0.536	-0.395	-0.360	-0.122
4100	2.44	-0.541	-0.475	-0.482	-0.513	-0.373	-0.370	-0.145
4200	2.38	-0.502	-0.463	-0.440	-0.465	-0.360	-0.352	-0.160
4300	2.33	-0.463	-0.408	-0.415	-0.435	-0.316	-0.313	-0.148
4400	2.27	-0.417	-0.380	-0.370	-0.390	-0.299	-0.277	-0.152
4500	2.22	-0.395	-0.340	-0.335	-0.355	-0.260	-0.255	-0.120
4600	2.17	-0.345	-0.305	-0.302	-0.315	-0.240	-0.225	-0.125
4700	2.13	-0.318	-0.260	-0.265	-0.275	-0.217	-0.200	-0.100
4800	2.08	-0.270	-0.234	-0.230	-0.240	-0.183	-0.175	-0.100
4900	2.04	-0.250	-0.190	-0.201	-0.200	-0.160	-0.126	-0.083
5000	2.00	-0.209	-0.160	-0.160	-0.175	-0.135	-0.120	-0.068
5100	1.96	-0.160	-0.130	-0.135	-0.135	-0.102	-0.080	-0.048
5200	1.92	-0.115	-0.090	-0.093	-0.103	-0.087	-0.068	-0.050
5300	1.89	-0.083	-0.065	-0.065	-0.070	-0.060	-0.050	-0.043
5400	1.85	-0.052	-0.025	-0.025	-0.045	-0.030	-0.020	-0.020
5500	1.82	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5600	1.79	0.027	0.050	0.045	0.030	0.025	0.024	0.000
5700	1.75	0.038	0.070	0.070	0.080	0.060	0.065	0.022
5800	1.72	0.075	0.095	0.100	0.095	0.075	0.064	0.025
5900	1.69	0.120	0.150	0.147	0.132	0.099	0.090	0.032
6000	1.67	0.150	0.170	0.168	0.152	0.126	0.100	0.037
6100	1.64	0.157	0.200	0.210	0.215	0.145	0.119	0.045
6200	1.61	0.180	0.240	0.225	0.235	0.175	0.132	0.044
6300	1.59	0.200	0.267	0.260	0.265	0.205	0.160	0.060
6400	1.56	0.240	0.280	0.280	0.275	0.220	0.180	0.056
6500	1.53	0.250	0.319	0.315	0.310	0.230	0.200	0.055
6600	1.51	0.265	0.338	0.330	0.338	0.268	0.220	0.050
6700	1.49	0.304	0.370	0.362	0.375	0.285	0.220	0.057
6800	1.47	0.325	0.383	0.383	0.402	0.305	0.255	0.059
6900	1.45	0.360	0.420	0.410	0.425	0.320	0.275	0.060
7000	1.43	0.375	0.452	0.435	0.440	0.334	0.283	0.080
7100	1.41	0.392	0.465	0.455	0.475	0.355	0.284	0.070
7200	1.39	0.407	0.485	0.480	0.500	0.375	0.320	0.077
7300	1.37	0.422	0.530	0.500	0.503	0.390	0.345	0.080
7400	1.35	0.444	0.547	0.538	0.540	0.410	0.370	0.074
7500	1.33	0.458	0.565	0.575	0.565	0.433	0.385	0.085
7600	1.31	0.470	0.596	0.586	0.565	0.445	0.387	0.075
7700	1.29	0.482	0.627	0.610	0.605	0.468	0.403	0.096
7800	1.27	0.505	0.630	0.625	0.600	0.495	0.405	0.080
7900	1.25	0.515	0.644	0.665	0.638	0.497	0.402	0.075
8000	1.23	0.525	0.680	0.690	0.700	0.508	0.410	0.074

TABLE III

De-reddened monochromatic magnitudes of normal B stars normalised to wavelength λ5500 Å

λ (Å)	$1/\lambda$ (μ^{-1})	10 Lac	HR 8733	8 Cyg	9 Vul	2 And
3200	3.13	$-0\overset{\mathrm{m}}{.}695$	$-0\overset{\mathrm{m}}{.}480$	$-0\overset{\mathrm{m}}{.}385$	$0\overset{\mathrm{m}}{.}375$	$1\overset{\mathrm{m}}{.}720$
3300	3.03	-0.662	-0.405	-0.315	0.400	1.626
3400	2.94	-0.625	-0.365	-0.310	0.395	1.587
3500	2.86	-0.615	-0.350	-0.295	0.385	1.535
3600	2.78	-0.577	-0.335	-0.248	0.375	1.450
3700	2.70	-0.502	-0.300	-0.235	0.300	1.357
3800	2.63	-0.460	-0.270	-0.285	-0.050	0.538
3900	2.56	-0.510	-0.365	-0.355	-0.325	0.180
4000	2.50	-0.555	-0.440	-0.412	-0.375	0.010
4100	2.44	-0.545	-0.475	-0.457	-0.370	-0.108
4200	2.38	-0.483	-0.452	-0.438	-0.352	-0.115
4300	2.33	-0.450	-0.415	-0.400	-0.315	-0.120
4400	2.27	-0.400	-0.380	-0.373	-0.290	-0.112
4500	2.22	-0.370	-0.332	-0.330	-0.260	-0.100
4600	2.17	-0.330	-0.300	-0.308	-0.230	-0.090
4700	2.13	-0.300	-0.250	-0.270	-0.210	-0.075
4800	2.08	-0.260	-0.235	-0.233	-0.175	-0.080
4900	2.04	-0.217	-0.182	-0.200	-0.135	-0.065
5000	2.00	-0.180	-0.170	-0.170	-0.115	-0.063
5100	1.96	-0.138	-0.130	-0.130	-0.100	-0.035
5200	1.92	-0.105	-0.090	-0.108	-0.060	-0.037
5300	1.89	-0.065	-0.070	-0.063	-0.050	-0.022
5400	1.85	-0.030	-0.020	-0.028	-0.025	-0.002
5500	1.82	0.000	0.000	0.000	0.000	0.000
5600	1.79	0.040	0.038	0.020	0.020	0.010
5700	1.75	0.070	0.085	0.055	0.058	0.020
5800	1.72	0.090	0.095	0.085	0.070	0.038
5900	1.69	0.125	0.125	0.115	0.100	0.045
6000	1.67	0.155	0.175	0.140	0.120	0.057
6100	1.64	0.195	0.195	0.185	0.145	0.070
6200	1.61	0.238	0.226	0.215	0.162	0.070
6300	1.59	0.275	0.250	0.220	0.205	0.095
6400	1.56	0.290	0.258	0.263	0.220	0.110
6500	1.53	0.338	0.299	0.285	0.250	0.100
6600	1.51	0.350	0.323	0.310	0.280	0.122
6700	1.49	0.380	0.358	0.315	0.295	0.135
6800	1.47	0.410	0.375	0.340	0.300	0.156
6900	1.45	0.430	0.400	0.365	0.340	0.152
7000	1.43	0.470	0.425	0.390	0.350	0.182
7100	1.41	0.503	0.450	0.435	0.365	0.185
7200	1.39	0.515	0.485	0.450	0.640	0.204
7300	1.37	0.540	0.495	0.480	0.410	0.208
7400	1.35	0.585	0.520	0.500	0.448	0.227
7500	1.33	0.610	0.565	0.540	0.470	0.235
7600	1.31	0.620	0.562	0.575	0.473	0.250
7700	1.29	0.662	0.612	0.590	0.515	0.270
7800	1.27	0.680	0.655	0.620	0.517	0.275
7900	1.25	0.720	0.690	0.645	0.530	0.298
8000	1.23	0.750	0.725	0.675	0.570	0.320

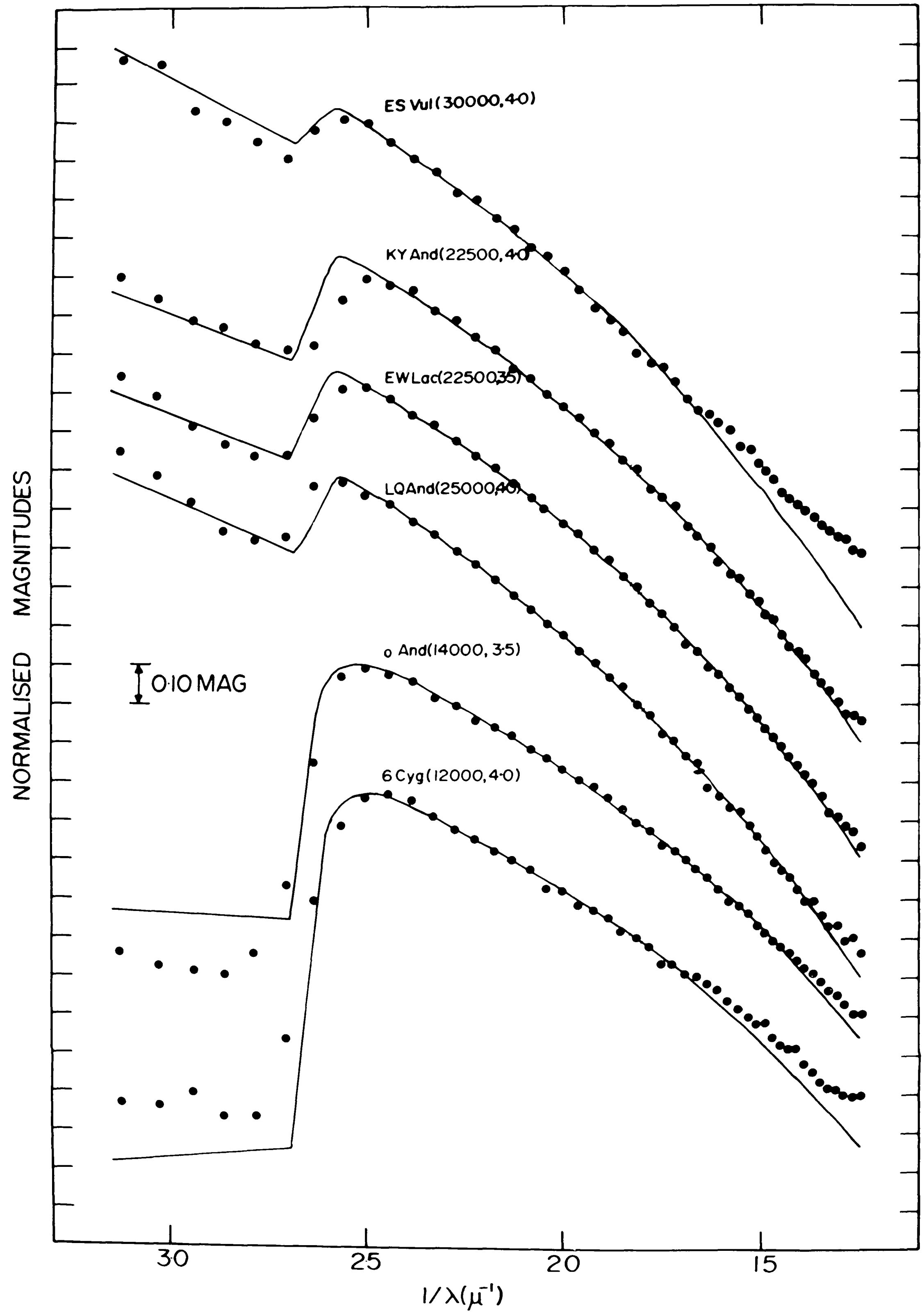

Fig. 1. Normalised de-reddened energy distribution curves of Be stars (filled circles) superimposed by best fitting models (solid continuous curves). The normalisation have been done at λ5500 Å. The matching has been done by eye.

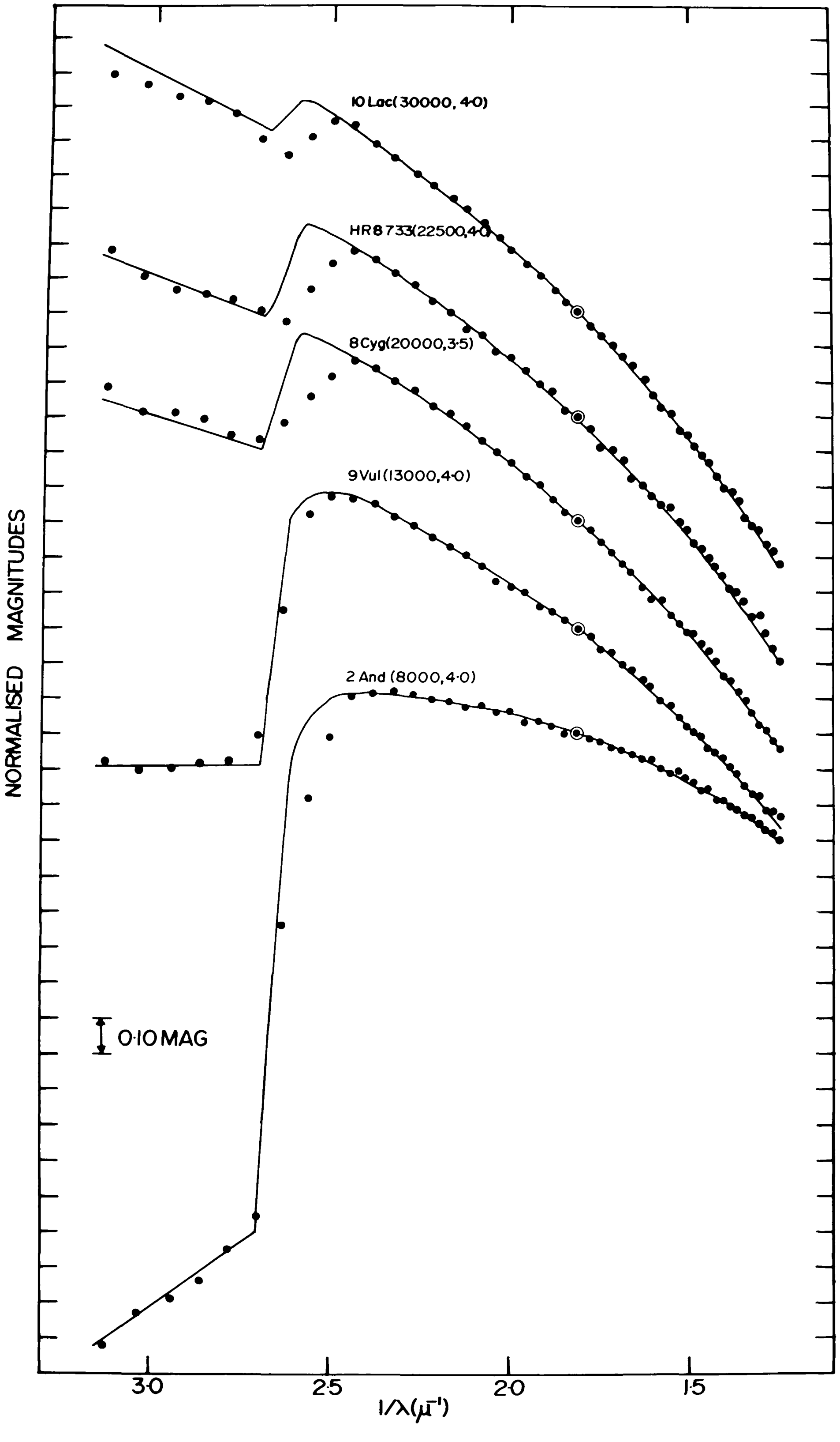

Fig. 2. This figure is the same as Figure 1 but for normal B stars.

extinction coefficients used were checked nightly by the observations of standards.

Five normal B stars, to serve as comparisons, were also observed alongwith Be stars to define the effective temperatures and Balmer jumps of normal stars as well as to check colour excess and the details of the interstellar reddening law. Also, normal B stars were used to check the temperature scale of Kurucz (1979) models. With the help of standard stars the absolute continuum fluxes of program stars were extracted. Our transformation of observations to absolute values of program stars corresponds to the absolute calibration system of Tug *et al.* (1977). The absolute monochromatic fluxes of program stars were extracted at upto 49 wavelengths separated by 100 Å. The standard deviation of the measurements on an individual night does not exceed $\pm 0\overset{m}{.}03$ in the entire wavelength range. The magnitudes of program stars were corrected for interstellar reddening and were normalized to wavelength $\lambda 5500$ Å. The de-reddened normalised magnitudes are listed in Tables II and III. These are plotted in Figures 1 and 2.

3. Correction for Interstellar Reddening

The determination of interstellar reddening for Be stars is complicated due to their high-rotational velocities. Rapid rotation introduces an intrinsic reddening which is significant for the rapidly rotating Be stars. A neglect of this effect yields an overestimate of interstellar reddening which, in turn, yields an over-correction of ultraviolet fluxes resulting in a spurious ultraviolet excess. Briot (1978) has found that an ultraviolet flux excess for B0e stars is related to an overestimate of interstellar reddening correction. Llorente de Andres *et al.* (1981) have also shown that rapid stellar rotation introduces an additional reddening (intrinsic rotational reddening) which produces an overestimate of the corrections for interstellar extinction. This overestimate of reddening correction results in an ultraviolet flux excess observed for many Be stars.

The direct measurement of $E(B - V)$ neglects the effect of intrinsic reddening in Be stars. The normal Q-method of Johnson and Morgan (1953), valid for the Main-Sequence O and B stars, is likely to produce large errors because of an ultraviolet and near-infrared excess emissions in a few of Be stars.

In order to account for intrinsic rotational reddening in Be stars we have used the distance moduli method for the determination of colour excess $E(B - V)$ of Be stars. To determine interstellar reddening, we plotted colour excess $E(B - V)$ (of about 100 normal B stars lying in the direction of the program stars) against their apparent distance moduli $(m_v - M_v)$. The $E(B - V)$ values for normal B stars were computed through the Q-method. The normal B stars were selected from the photoelectric catalogue of Blanco *et al.* (1968). To estimate apparent distance moduli of normal B stars the M_v magnitudes were taken from the spectral type and luminosity class versus M_v calibration for early-type stars (Allen, 1976). From the distance modulus versus $E(B - V)$ relation for normal B stars the $E(B - V)$ values of program Be stars corresponding to their distance moduli were estimated. The $E(B - V)$ values of Be stars, thus, estimated are listed in Table I alongwith the expected errors. The $E(B - V)$ values of normal B stars are those adopted from the *Ultraviolet Bright Star Spectrophotometric Catalogue* (Jamar *et al.*, 1976). The reddening corrections were calculated by adopting a mean value of total-to-selective extinction; $R = 3.25$ (Moffat and Schmidt-Kaler, 1976) and using the interstellar reddening curve given by Lucke (1980) for the particular region.

4. Continua and Effective Temperatures

The continuum of a Be star is contaminated with emission from circumstellar envelope. As a result of which many Be stars have Balmer jump either in emission or in absorption and near-infrared excess emission. The effect of rotation on continuum for B-type stars has been studied theoretically by Hardorp and Strittmatter (1968). They have shown that the rotational effect is nearly equivalent to lowering the effective temperatures for equator-on-stars. The geometrical effects of pole-on-stars slightly increase the surface gravity: those of equator-on ($i = 90$) decrease it by as much as $\log g = 1$. The continuum of a Be star is made up of: (a) stellar radiation; (b) envelope emission; and (c) scattered radiation.

Both the scattered and the stellar components of the continuum increase with decreasing inclination, due to decrease of the optical depth through the envelope. Also, the emissions from the envelope increase with decreasing inclination because of the decrease in the pathlength through the envelope and also because of the increased area of the envelope seen by the observer for those wavelengths at which the substantial parts of the envelope are optically thick.

We have used the synthetic spectra constructed by Kurucz (1979) with normal chemical composition for deriving effective temperatures of stars. Kurucz models were computed assuming plane parallel geometry, hydrostatic equilibrium, local thermodynamic equilibrium, no molecules with equation of state and radiative plus convective energy transport. Line blanketing was included by use of a statistical distribution function, representation of the opacity of almost one million atomic lines. We have already tested Kurucz models against normal stars and have found very good overall agreement. In the present paper also it is clear from Figure 2 that the Kurucz synthetic models represent the observed spectra of normal B stars very well over the whole observed spectral range. Also, the fitted models resemble the values of effective temperatures of normal B stars corresponding to their spectral type and luminosity class.

Kurucz model atmospheres with solar abundances and microturbulence velocity of 2 km s^{-1} were superimposed on the observed spectra for deriving the effective temperatures; assuming $\log g = 4.0$ for luminosity classes V and IV and $\log g = 3.5$ for luminosity class III. The models (solid continuous curves) fitted with the observations (filled circles) are shown in Figures 1 and 2. The numbers in the brackets in Figures 1 and 2 denote the values of T_{eff} and $\log g$, respectively, of the best fitted models. The temperatures derived are listed in Table I. The effect of gravity on the energy distributions of these stars is relatively small. For example, a change in gravity from $\log g = 4$ to $\log g = 2$ would be equivalent to a change in temperature less than 500 K at 10000 K (Kontizas and Theodossiu, 1980). Therefore, in using fluxes to determine the temperatures of Be stars, the gravity will not need to be known with great accuracy (Nandy and Schmidt, 1975).

The uncertainty in temperature due to photometric error of the observed fluxes is ± 5% around 25 000 K and ± 2% around 10 000 K. The fit of the computed to the observed fluxes introduces an additional error that varies from ± 500 K for cool stars to ± 800 K for the hot ones. The temperatures derived here are plotted on the θ_{eff}-spectral type relation for normal B stars as shown in Figure 3. In Figure 3 we have also plotted normal B stars included in the present study. The solid curve in Figure 3 for normal B stars was obtained from the T_{eff} and spectral-type data for early-type stars given by Kontizas and Theodossiu (1980).

Figure 3 reveals that all stars except KX And follow the θ_{eff}-spectral type relation for normal B stars well. This Be shell star deviate strongly from the mean relation for normal

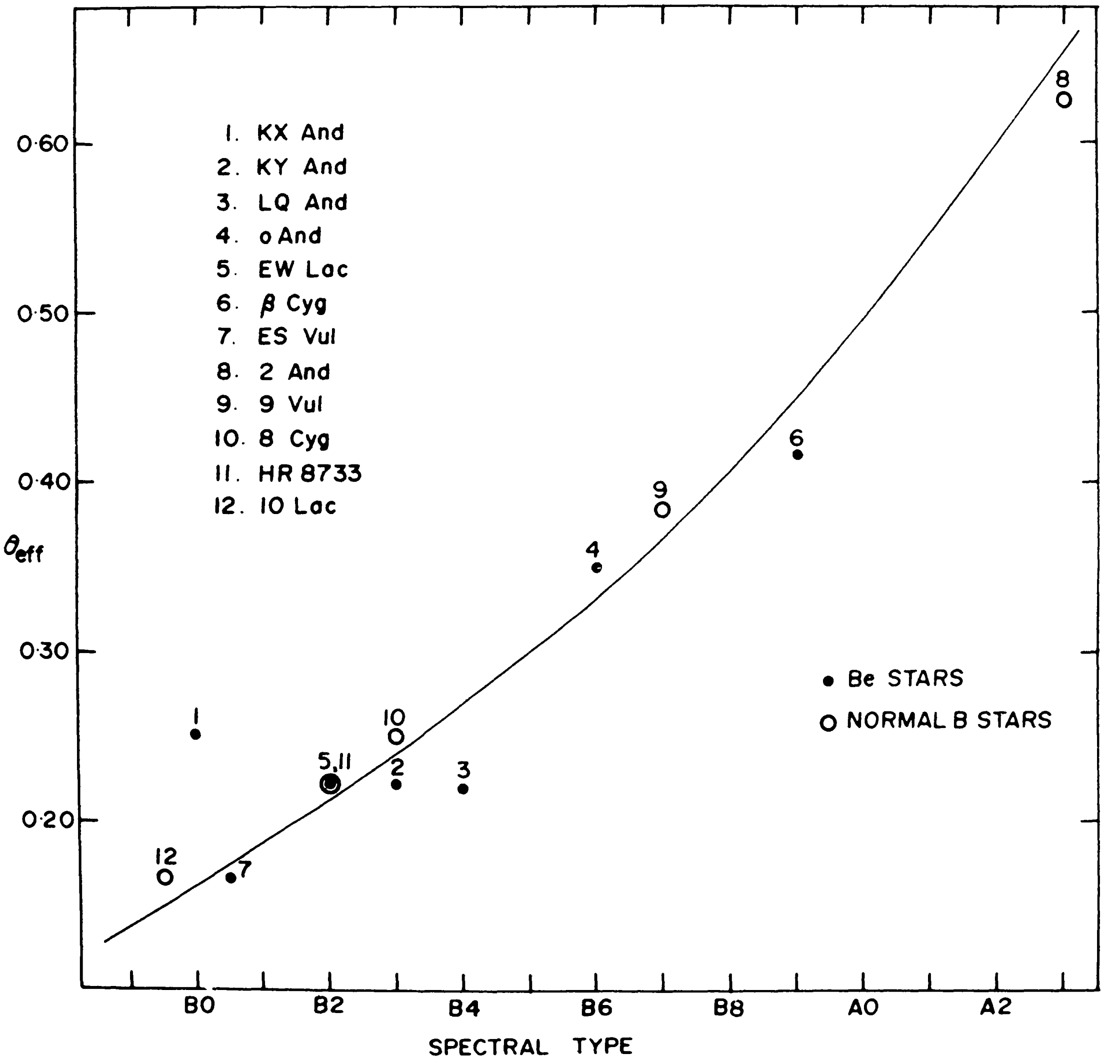

Fig. 3. Position of observed stars (filled and open circles) on the θ_{eff}-spectral type relation for normal B stars. The solid continuous curve is the mean relation for normal B stars.

B stars. KX And shows lower effective temperature than that of the corresponding normal B star.

The Be shell star KX And could not be fitted by any of the model atmospheres. The energy distribution of this peculiar star will be discussed later in detail.

5. Discussion Concerning Individual Be Stars

The Be stars studied here are listed in Table I. From the seven Be stars, the four Be stars, namely ES Vul, KY And, LQ And, and 6 Cyg have poorly been studied earlier. The rest three stars, EW Lac, *o* And, and KX And are among the most extensively studied Be stars. The Be shell star KX And is one of the most interesting objects and will be discussed in detail.

ES Vul. This B0.5IV Be star is variable. The variability of this stars was first pointed out by Plaskett and Pearce (1930) and confirmed by Lynds (1959). The observations by Lynds show a definite light-variation of about $0\overset{m}{.}060$ with a period of 0.6096 days.

Figure 1 shows that ES Vul has moderate near-infrared excess emission longward of wavelength $\lambda 6000$ Å. This star shows normal Balmer jump.

KY And. This star has a quasi-permanent hydrogen shell of variable strength. The variability of this star was discovered by Hill (1967) and later confirmed by Hill *et al.* (1976). They claimed that the variability is rapid. The *V* magnitude varies for at least $0\overset{m}{.}1$. Harmanec *et al.* (1980) found from *UBV* measurements that the *V* magnitude varies by as much as $0\overset{m}{.}2$.

As is seen from Figure 1, this star shows normal continuum energy distribution in the whole observed range of wavelength.

EW Lac. EW Lac (B2IIIpe, shell) is one of the most frequently observed Be shell stars. Its variation was detected by Walker (1953) and later confirmed by Lester (1975). The amplitude of the variation amounts to as much as $0\overset{m}{.}2$. The envelope of this star was stable from 1926 to the end of 1977. The instability of the shell was discovered by Hadrava *et al.* (1978). Harmanec *et al.* (1979, 1980), Hirata and Kogure (1979), and Kogure *et al.* (1981) have reported the changes in its spectrum and colours in 1978, after a long stable shell-star phase. Poeckert (1980) and Scholz (1982) have made a detailed study on the line strength changes during 1978–1979. Scholz (1981) suggested that EW Lac may be an interacting binary system with the possible existence of a cool companion.

No excess or deficiency in the mean flux of this star has been detected in the present study.

LQ And. This B4Vn Be star has been poorly observed. Its photometric variability was first discovered by Percy (1981). He found that this star is variable on time-scales of hours to days. This star shows no peculiarity in the continuum energy distribution as is clear from Figure 1.

o And. o And is one of the most frequently observed Be stars. This star has variously been attributed to different kinds of light variations. Detailed spectroscopic and photometric investigation of the variations are published in a series of papers by Guthnick

(1941), Schmidt (1959), Olsen (1972), Bossi *et al.* (1976, 1977), Gulliver and Bolton (1978), Gulliver *et al.* (1980), Baade (1981), Pastori *et al.* (1982), and Horn *et al.* (1982).

o And underwent a shell phase in 1981 and is still in shell phase (Bossi *et al.*, 1982; and Hayes, 1982). Recently, Harmanec (1984) has discussed the puzzle connected with *o* And. According to him this star is a favourable object which could help in our unstanding the Be phenomenon.

The observed continuous energy distribution of *o* And in Figure 1, reveals that this star has Balmer jump in absorption. This deficiency of flux in the Balmer jump region offers a convincing evidence for this star's recent shell episode.

6 Cyg. This late Be star (B9V) is the least studied Be star. It is not seen to be a variable. The continuous energy distribution of this star is shown in Figure 1. This star shows peculiar continuous energy distribution. Figure 1 reveals that this star has near-ultra-violet and near-infrared excess emissions.

KX And. This star has given rise to detailed studies. This is a well-known shell star exhibiting pronounced spectral variations. Struve (1944), Merrill (1949), Holliday (1950), and Doazan and Peton (1970) noticed spectroscopically a series of changes in its spectrum. Kříž and Harmanec (1975) suggested the binary nature of this star. Later on, Polidan and Peters (1976) proved its binary nature. Harmanec *et al.* (1977, 1980)

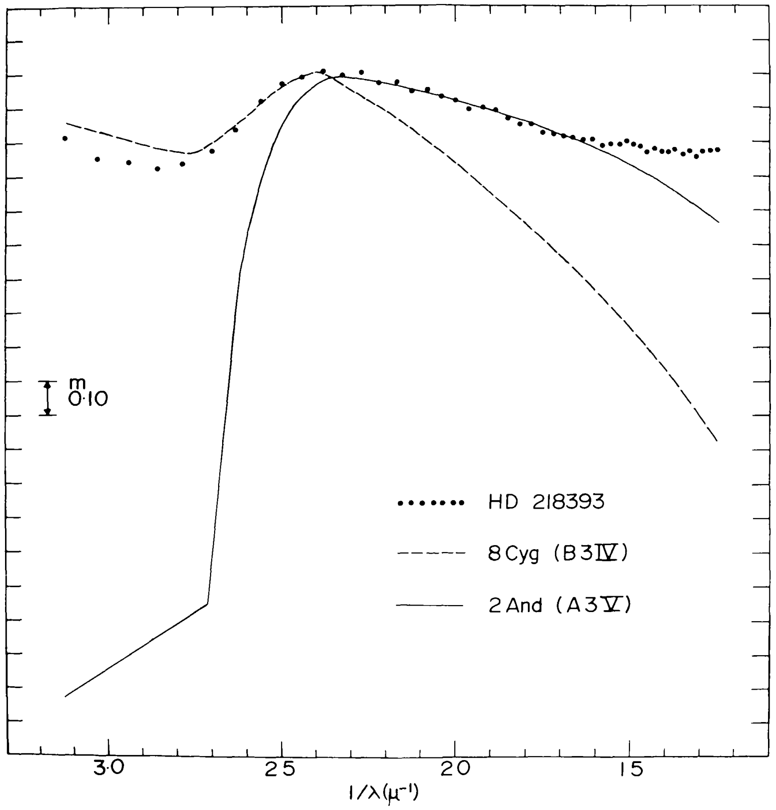

Fig. 4. Observed energy distribution curve of KX And (HD 218393) compared with an early-type star 8 Cyg (B3IV) and a late-type star 2 And (A3V).

discovered the photometric variability of this star ($\Delta U = 0\overset{m}{.}3$, $\Delta B = \overset{m}{.}1$, and $\Delta V = 0\overset{m}{.}1$). Recently, Paterson-Beeckmans *et al.* (1982) suggested the existence of an extended atmosphere accelerated outwards in 1979.

The observed continuum energy distribution of KX And is shown in Figure 4. The energy distribution curve of this star could not be fitted with any Kurucz models over the whole observed spectral range. In Figure 4 we have compared the energy curve of KX And with 2 And (A3V) and 8 Cyg (B3IV). We found that the observed curve of KX And matches with 8 Cyg in the Balmer jump region ($\lambda\lambda$3200–4200 Å). Some part of the Paschen continuum region ($\lambda\lambda$4200–6000 Å) of KX And matches well with 2 And. A near-infrared excess longward of λ6000 Å was also noticed for KX And. From the observed composite energy distribution we infer that the continuum of KX And is a combination of the spectrum of hotter primary component (early B-type) and the cooler companion (K-type).

The observed peculiarities in the continuum of KX And suggest that the object is an interacting binary star, consisting of B-type primary and K-type secondary. The near-infrared excess emission longward of λ6000 Å is due to the circumstellar envelope emission.

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