

Spectroscopic Study of Four Members of Balmer Series in Be Stars

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The present work is a part of our on-going “International Observing Campaign” to observe large number of bright Be stars. The spectra of Be stars is characterized mainly by the presence of emission lines in the central part of the first few members of the Balmer series of Hydrogen. Sometimes, these emission lines show no reversal; and on occasions central emission may get split up midway into two components by a depression, giving a double peaked shape. This emission at Balmer series may continue up to about H15 and even more; and after that absorption lines occur like normal B-star. In this communication we report the spectroscopic analysis of four members of Balmer series of Hydrogen in four Be stars. It is found that all the four Be stars show H α line strongly in emission. Three stars show H β , H γ , H δ strongly in absorption with weak emission components. Only one star shows H β also strongly in emission with two components lying over the underlying absorption. We have also measured the parameter of the lines like: equivalent width (W).

Key Words: Be star, Balmer series, Emission lines, Absorption lines

INTRODUCTION

It has been known for many years that, generally, some of the Balmer lines of hydrogen are in emission in the spectra of B-type stars that show Be spectra. Usually there is a strong emission at H α and weaker emission at H β and some lines at H γ . The strength of emission goes on decreasing as we move towards higher member of the Balmer series; and ultimately the lines show absorption component only. The existence of a rather cool equatorial disk in Be stars is well established since 1931 Struve¹. The detailed investigations of these objects prior to 1970 have been made by Struve², Merrill & Sanford³, Hiltner⁴, Merrill⁵, Underhill⁶⁻⁹, Jaschek *et al.*¹⁰ and Faraggiana¹¹. As several authors have also stressed that it is highly desirable to carry-on the survey of bright and homogeneous sample of a large number of Be/shell stars. The continuous monitoring of well defined objects is highly necessary to investigate variability on different time scales and to reach at some definite conclusion. Realising the importance of the objects and to understand them in a better way we undertake

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an extensive spectroscopic observational programme of emission and shell lines in Be/shell stars.

OBSERVATIONS AND DATA REDUCTION

The observations of these four stars were carried out on 7 December, 2006 by using IUCAA's 2m telescope mounted with Faint Object Grism Spectrograph (IFOSC7) having resolution of 4.4\AA and blazed to 5000\AA . The instrument is mounted at the telescope's direct Cassegrainian port. IFOSC7 employs an EEV $2k \times 2k$ thinned black illuminated CCD with $13.5\mu\text{m}$ having a field of view of about 10.5arcmin . Long-slit of $100\mu\text{m}$ width was used in front of the spectrograph. The reduction of the data has been standard. The steps were bias subtraction, division by the normalized flat field, wavelength calibration and normalization to the stellar continuum. The wavelength calibration was carried out by using the helium neon comparison spectrum.

RESULTS AND DISCUSSION

The $H\alpha$, $H\beta$, $H\gamma$ and $H\delta$ line profiles of observed Be stars are displayed in Fig. 1 and 2.

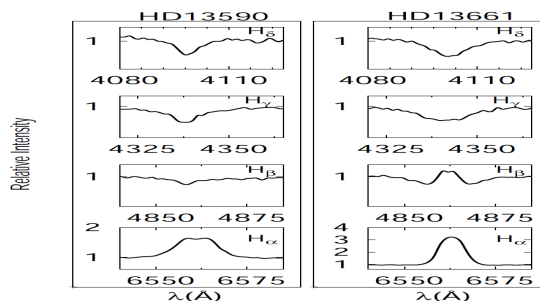


Fig. 1. Profiles of Balmer series of HD13590 and HD13661

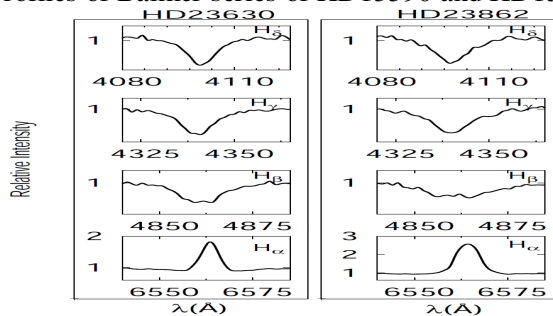


Fig. 2. Profiles of Balmer series of HD23630 and HD23862

The stars of the present study are listed in Table 1.

TABLE- 1
PARAMETERS OF PROGRAMME BE STARS

HD No.	Mag.	Sp. T	Exp. T(s)	Equivalent widths(W) Å			
				H α	H β	H γ	H δ
13590	7.90	B2 IIIe	180	-10.28	2.87	3.89	3.49
13661	7.86	B2 IV-Ve	160	-20.46	2.13	4.33	4.41
23630	2.87	B7 IIIe	20	-3.61	5.20	6.00	6.88
23862	5.09	B8 Vpe	60	-14.28	5.02	6.51	6.34

It is obvious that all the four Be stars exhibited very strong emission at H α line, followed by very strong emission at H β line only in one star i.e. HD 13661. All other lines i.e. H β , H γ , H δ in other Be stars are seen in absorption some having weak emission components. The description of the observed behavior of four lines of Balmer series are given below:

HD 13590: The H α line for this star is remarkable for the width. The strong emission of this line about 36Å wide is divided by an absorption core about 6.5Å wide. The H β line is in sharp absorption with a width of about 50Å. It is an asymmetrical line which is strongly winged towards red with suspected features. The H γ absorption is also asymmetrical about 35Å wide with broad absorption core. The H δ line exhibited sharp absorption core and is 18Å wide.

HD 13661: This Be star exhibited very strong symmetrical single-peaked sharp emission; with 19Å width, at H α . Its shoulders are well defined and lie over the underlying continuum. The H β absorption about 40Å wide superimposed with central strong emission is a fascinating feature of this line. The H γ line about 45Å wide is also in absorption with broad core. The core is superimposed with very weak emission component. H δ line with 28Å width is also seen in absorption with weak central emission component. It is winged towards red.

HD 23630: The H α line emission appeared symmetrical with sharp single-peaked profile of moderate strength having about 10Å width. The emission line emerged from the underlying disk shaped absorption profile. The sharp violet and red edges still lie below the continuum level. The H β appeared as an absorption line of about 40Å width. The structure of H γ is somewhat different, here the central emission is very much weaker. H γ is also in absorption and is about 40Å wide asymmetrical line slightly winged towards red. At H δ , no central emission remains. The line is totally in absorption with sharp core and about 22Å wide.

HD 23862: H α line in this star also is single-peaked, strong and almost symmetrical with about 18Å width. The profile of H β is totally different, where the broadened absorption line is seen with the width of about 50Å. The absorption core of H β is superimposed with two unequal emission features separated by about 35Å. The H γ line is seen completely in absorption having a

width of about 36Å slightly shaded towards red, with more intensity. The Hδ line is again in absorption with a width of about 22Å having more intensity of emission borders on either side.

Conclusion

It is found that all the four Be stars show Hα line strongly in emission. Three stars show Hβ, Hγ, Hδ strongly in absorption with weak emission components. Only one star shows Hβ also strongly in emission with two components lying over the underlying absorption. The observed emission in these stars is originated from the circumstellar envelopes surrounding these objects.

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REFERENCES

1. O. Struve, *Astrophys. J.*, **73**, 94 (1931).
2. O. Struve, *Astrophys. J.*, **98**, 98 (1943).
3. P.W. Merrill and R.F. Sanford, *Astrophys. J.*, **100**, 14 (1944).
4. W.A. Hiltner, *Astrophys. J.*, **99**, 103 (1944).
5. P.W. Merrill, *Publ. Astron. Soc. Pacific.*, **65**, 113 (1953).
6. A.B. Underhill, *Mon. Not. Royal Astron. Soc.*, **113**, 477 (1953).
7. A.B. Underhill, *Publ. Dominion Astrophys. Observatory*, Victoria, BC. **9**, No. 12, p. 363 (1953).
8. A.B. Underhill, *Astron. Soc. Pacific Leaflets*, **7**, 73 (1955).
9. A.B. Underhill, *Publ. Astron. Soc. Pacific.*, **69**, 401 (1957).
10. C. Jaschek, M. Jaschek and B. Kuclwicz, *Zeitsch. Astrophys.*, **59**, 108 (1964).
11. R. Faraggiana, *Astron. Astrophys.*, **2**, 162 (1969).