Line variations of H$\alpha$ emissions and absorptions of Be stars

To cite this article: Aprilia et al 2019 J. Phys.: Conf. Ser. 1153 012146

View the article online for updates and enhancements.
Line variations of H$\alpha$ emissions and absorptions of Be stars

Aprilia¹, R. Muztaba, M. Irfan, E. Puspitaningurm, G.E. Ramadhangia and H.L. Malasan
Department of Astronomy and Bosscha Observatory, Faculty of Mathematics and
Natural Sciences, Institut Teknologi Bandung,
Jl. Ganesha No. 10 Bandung, INDONESIA
E-mail: aprilia@as.itb.ac.id

Abstract. We present the spectroscopic variations of 14 program Be stars observed within 2008 – 2009 at the Bosscha Observatory, Lembang, Indonesia, using Zeiss Double Refractor equipped with Bosscha Compact Spectrograph. The Be stars show spectroscopic profiles as Be and Be-shell, and sometimes as B-normal. These profiles originate from the disk-like envelope or rings surrounded the star’s equatorial plane. Our program stars are: 5 as Be single-peaked, 2 as Be double-peak, and 7 as B-normal stars. We also measure the Ip/Ic ratio from the line profiles.

1. Introduction
B-emission (Be) stars are B-type stars characterized by Balmer emission (e.g. H$\alpha$ lines) that originate in a circumstellar matter (envelope) surrounding the stars [1][9]. Be stars rotate rapidly (100 – 400 km/s, or more). Their rotation rates are typically 70 – 80 % of their critical rotational velocities [9]. It is indicated that this rapid rotation is one of the cause of the envelope formation around the star. Spectral lines of Be stars show three main profiles [2]: Be single-peaked, Be double-peaked, and Be-shell line profiles. The profiles Be and Be-shell are different in the depth and sharpness of the absorption lines in between the emission lines, where for the Be-shell, the absorption lines are deep enough below the continuum [8][13]. These profiles are caused by the evolution of envelope formation around the stars. Therefore, it is possible for the stars to have phase profile changing, from Be to Be-shell, or become B-normal again, or vice versa, for some duration of times, typically within years. The mechanism that drives these kind of phenomena is still a topic of discussion nowadays [11]. It also seems that one mechanism that fits to one stars, may not fit to other Be stars [6].

The emission line spectrum of Be stars show some variations, among others V/R and Ip/Ic. The V/R is time variation of relative intensities of violet (V) and red (R) components in double-peaked emission-line profiles, while Ip/Ic is time variation of emission-line intensities (Ip) relative to the adjacent continuum (Ic) [5]. These variations can quantify the strength of H$\alpha$ line.

In this work, we present the spectroscopic observations of the H$\alpha$ lines at 6563 Å of 14 program Be stars observed in 2008 – 2009. The H$\alpha$ lines are typically the strongest features, formed over a large region in the disk [14]. We also measure the Ip/Ic variation of the emission-line profiles. We have discussed the V/R variation of some of our Be stars and published in [12].
2. Numerical Methods

2.1. Observations and Data Reduction

The 14 program Be stars have been observed spectroscopically at the Bosscha Observatory, Lembang, Indonesia, in 2008 – 2009, by using the 60cm Zeiss Double Refractor equipped with Bosscha Compact Spectrograph (BCS) and SBIG ST-8XME CCD camera. These stars are listed in the Bright Stars Catalogue (BSC) [4]. The spectrograms were reduced using the IRAF (Image Reduction and Analysis Facility) package from NOAO (National Optical Astronomy Observatories). We have to calibrate data with bias, dark, and flat-filed images. The resulted spectrogram that is already free from the noise then has to be changed to the one-dimension spectra. The next step is the transformation of the image coordinates from pixels to wavelength scales, and then the normalization the stellar spectra to their continuum. The standard procedure of the spectral reduction can be accessed from http://iraf.noao.edu/.

3. Results and Discussions

Parameters related to the program stars are listed in Table 1. Column 1 gives the name of the program star in BSC. Column 2 shows the visual magnitude of the stars. Visual magnitude is the brightness of the star in visual wavelength: the smaller the magnitude, the brighter the star is. Data in column 3 are the spectral type of the program stars: all stars are B-type stars with the luminosity classes of subgiants (IV), giants (III), and main sequence (V). Data in column 4 are the rotation velocities for each star. The parameters in column 2 – 4 are taken from several references, while Ip/Ic values in column 5 are our measurement from our observed line profiles.

| Name   | V mag | Spectral type | v sin i (km/s) | Ip/Ic |
|--------|-------|---------------|---------------|-------|
| HR 5953 | 2.32  | B0.3IV        | 180           | 10    |
| HR 6141 | 4.79  | B3V           | 232           | 5.18  |
| HR 6881 | 5.71  | B5Ve          | 250           | 3.3   |
| HR 7342 | 4.58  | Bpshe         | 133           | 5.31  |
| HR 7890 | 6.22  | B7IIIne       | 282           | 8.95  |
| HR 7106 | 3.52  | B7Ve          | 120           | 9.15  |
| HR 8402 | 4.70  | B7IVe         | 227           | 10.49 |
| HR 4638 | 3.96  | B3V           | -             | -     |
| HR 4898 | 4.04  | B2IV          | -             | -     |
| HR 5528 | 4.31  | B5IV          | -             | -     |
| HR 6700 | 4.73  | B9V           | 140           | -     |
| HR 6804 | 5.46  | B2III         | 197           | -     |
| HR 7166 | 5.52  | B3V           | -             | -     |
| HR 7739 | 4.76  | B3Ve          | 160           | -     |

Figure 1 shows the observed Hα profiles with various shape of emission and absorption lines. The profiles shown in Figure 1 consist of Be single-peaked for 5 stars, Be double-peaked for 2 stars, and B-normal for 7 stars. Below is the brief description for the observed line profiles of the program stars:

- The stars HR 5953, HR 6141, HR 6881, HR 7342, and HR 7890 show single-peaked emission line. These lines are strong enough above the continuum level

- The stars HR 7106 and HR 8402 show double strong emission peak. Both stars exhibit V/R variations: V/R = 0.7 for HR 7106 and V/R = 0.9 for HR 8402 [12]. HR 7106 is also known as an interacting-eclipsing and Algol-type binary star system, where one of the companion already fills its Roche lobe and transfers mass to the other star via a rapid gas stream, which makes this gainer star obscured by a geometrically and optically thick circumstellar disk [3]. The Hα profiles of HR
7106 are thought to come from this disk. HR 8402 is a subgiant Be star, which is in the process of evolving into a giant star, rotating rapidly with rotational rate 282 km s$^{-1}$ [7]. This evolution stage results the formation of the circumstellar disk of hydrogen gas that generates the emission H$\alpha$ profile.

- The stars HR 4638, HR 5528, HR 6700, HR 6804, HR 7166, and HR 7739 are in B-normal phases. Among these stars, only HR 6639 is indicated as a Be star.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{halpha_profiles}
\caption{H$\alpha$ line profiles of program stars}
\end{figure}

4. Conclusions
The program stars were observed in 2008 – 2009. The observed profiles exhibit various shapes of emission and absorption lines. Five stars are classified as Be single-peaked, two stars as Be double-peaked, and seven stars as B-normal stars. The Ip/Ic variations show that the stars have strong emission lines.

In order to see the evolution of the envelopes surrounding the stars, i.e. whether the stars exhibit phase profile changes for some duration of times, we need spectral data for some period. The data can be obtained from observation for several of weeks, or even years, or from the Be stars’ database. We are planning to do continuous observations for several years at the Bosscha Observatory for obtaining these variation profiles of our program stars. For early work, we compare our data to data taken from BeSS...
(Be Star Spectra) database [9], see also http://basebe.obspm.fr/basebe/. We get that most of the program stars do not show phase changes for these recent years. Only two stars show this changing: HR 6881, from Be single-peaked to Be double-peaked lines, and HR 7739, from B-normal to Be-shell. This indicates that the envelopes of the two stars have evolved, especially HR 7739 from not existed envelope to existed envelope. It might be that the envelope of the other stars takes longer periods (e.g. several years) to change.

Acknowledgments
Authors would like to thank to ITB for providing research fund to carry out this study from Research and Innovation Program Batch II, 2015: 834a/II.C01/PL/2015. This work has made use of the BeSS database, operated at LESIA, Observatoire de Meudon, France: http://basebe.obspm.fr.

5. References

[1] Collins GW 1987 *Physics of Be Stars IAU Colloq.* vol 92, ed. A Slettebak and TP Snow, Cambridge: Cambridge Univ. Press, p 3
[2] Doazan V 1982 *B Stars With and Without Emission Lines* (NASA SP-456)
[3] Gray SK and Ignace R 2008 *Journal of the Southeastern Association for Research in Astronomy* 2 71
[4] Hoffleit D and Jaschek C 1991 *Bright Star Catalogue 5th Revised Ed. (Preliminary Version)*, Yale University Observatory
[5] Kogure T and Leung K-C 2007 *The Astrophysics of Emission-Line Stars*, Berlin-Springer
[6] Malasan HL, Irfan M, Aprilia and Dawanas DN 2014 *The Tenth Pacific Rim Conference on Stellar Astrophysics* 482 25
[7] Meilland A, Millour F, Kanaan S, Stee Ph, Petrov R, Hofmann K –H, Natta A and Perraut K 2012 *Astronomy and Astrophysics* 538 A110
[8] Mon M, Suzuki M, Moritoni Y and Kogure T 2013 *Publication of the Astronomical Society of Japan* 65 77
[9] Neiner C, De Batz B, Cochrad F, Floquet M, Mekkas A and Desmoux V 2011 *Astronomical Journal* 142 149
[10] Owocki S 2006 *ASP Conference Series* 355 219
[11] Porter JM and Rivinius T 2003 *Pub. Astron. Soc. Pacific* 115 1153
[12] Puspitaningrum E, Muztaba R, Ramadhania GE, Irfan M, Aprilia and Malasan HL 2015 *Prosiding Seminar Sains Antarktika* p 174
[13] Rivinius T, Steff S and Baade D 2006 *Astronomy and Astrophysics* 459 137
[14] Silaj J, Jones CE, Tycner C, Sigut TAA and Smith AD 2010 *Astrophysical Journal Supplement Series* 187 228