https://doi.org/10.18524/1810-4215.2025.38.341537

SPECTRAL STUDY OF THE HERBIG Ae STAR HD 31648. THE Hα AND Hβ EMISSION LINES

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ABSTRACT. We present the results of observations of the Hα and Hβ lines in spectrum of Herbig Ae star HD 31648. Seven spectra from the Be Stars Spectra Database, with a spectral resolution of R $\approx$ 11,000, were used, along with three spectra obtained using the 2-m telescope at the Shamakhi Astrophysical Observatory with the Shamakhi Fiber Echelle Spectrograph (R $\approx$ 28,000). In the spectra at our disposal, the Hα line is predominantly observed as a P Cyg III type profile, characterized by a line intensity ratio of Ib/Ir $\ll$1 and in two cases it was observed as a classical P Cyg type profile – a red-shifted emission peak with blue-shifted absorption. There is no correlation in the changes in the intensity of the blue (Ib) and red (Ir) components. The blue component undergoes the greatest changes, and variability is also present in the intensity of the red emission peak. The Hβ line profile in the central part shows a P Cyg – type structure with wide photospheric wings. The red emission component of the Hβ line shows strong variability, which correlated with the red emission component of the Hα line. In general, variability in the profiles of the Hα and Hβ lines occur synchronously. In the work, a comparative analysis of the behavior of the Hα and Hβ lines is carried out using similar data from published data.

Keywords: pre-main sequence – stars: variables: Herbig Ae/Be: individual: HD31648.

АНОТАЦІЯ. Ми представляємо результати спостережень ліній Hα та Hβ у спектрі зорі типу Ae Хербіга — HD 31648. Для дослідження було використано сім спектрів із бази даних Be Stars Spectra Database зі спектральною роздільною здатністю R $\approx$ 11 000, а також три спектри, отримані на 2-метровому телескопі Шамахинської астрофізичної обсерваторії з використанням Шамахинського волоконного ешель-спектрографа (R $\approx$ 28 000). У наявних спектрах лінія Hα переважно спостерігається як профіль типу P Cyg III, що характеризується співвідношенням інтенсивностей синього та червоного компонентів Ib/Ir $\ll$1, а в двох випадках зафіксовано класичний профіль типу P Cyg — червонозміщений емісійний пік із синьозміщеним поглинанням. Кореляції між змінами інтенсивностей синього (Ib) і червоного (Ir) компонентів не спостерігається. Найбільших змін зазнає синій компонент, проте варіації також присутні в інтенсивності червоного емісійного піку. Профіль лінії Hβ у центральній частині показує структуру типу P Cyg із широкими фотосферними крилами. Червоний емісійний компонент лінії Hβ демонструє значну змінність, що корелює зі змінами червоного емісійного компонента лінії Hα. Загалом змінність профілів ліній Hα і Hβ проявляється синхронно. У роботі проведено порівняльний аналіз поведінки ліній Hα і Hβ із використанням аналогічних опублікованих даних.

Ключові слова: зорі до головної послідовності – змінні зорі до головної послідовності – Herbig Ae/Be — окрема зоря: HD 31648.

1. Introduction

The formation of stars and planetary systems is one of the primary research topics in modern astrophysics. Studies of young stars with small (stars T Tauri type) and intermediate (stars Ae/Be Herbig type) masses connected with early stages of stellar evolution are among the priority areas of astrophysics. At the beginning of the 21st century, considerable progress took place in the study of the physical processes of the interaction of a star and an accretion disk, also in the numerical simulation of various variants of the formation of a stellar wind and star accretion of matter.

Comparison of the observed characteristics of young stars with model calculations requires sufficiently long-term spectral observations, which make it possible to estimate the characteristic time of accretion and wind variability.

According to modern astrophysical concepts, the physics of the observed particularities of young stars type Ae/Be Herbig, in general, is determined by the

results of the interaction between the young star and the surrounding circumstellar medium.

The goal of this message: based on the spectral data of the young star type Herbig Ae HD31648, to study the observed peculiarities of the star's emission in the regimes of accretion and stellar wind.

HD 31648 (MWC480) is an isolated Herbig Ae star in the Taurus-Auriga star-forming region, spectral class of the star is A2-A3e, one of the brightest (V $\sim$ $7^m.6$) stars of this type in the northern sky. The star HD31648 belongs to the group of photometrically quiet young stars with signs of matter outflow in the spectrum. Its age is estimated 2,5–7 million years, star mass $M_* = (1.65 - 2.2)\ M_\odot$, luminosity $L_* = (11.2 - 32.4)\ L_\odot$, $R_* = 1.67\ R_\odot$, $T_{eff} = 8250 - 8710$ K (Augereau et al., 2001; Montesinos et al., 2009).

The star HD31648 has been studied in detail spectroscopically in the optical range mainly in the following works: Beskrovnaya and Pogodin, 2004; Kozlova, Grinin and Chuntonov, 2003; Kozlova, Alekseev and Shakhovskoi, 2007; Mendigutia, Eiroa, Montesinos et al., 2011; Mendigutia, Brittain, Eiroa et al., 2013; Tambovtseva et al., 2016.

2. Observations and data reduction

Seven spectra from the Be Stars Spectra Database, with a spectral resolution of R $\approx$ 11,000, were used, along with four spectra were carried out at the Cassegrain focus of the 2-m telescope of the Shamakhi Astrophysical Observatory, on fiber echelle spectrograph (ShAFES) with the spectral resolution of R = 28,000. During the period December 2019 – January 2020 on every four nights, 2 spectra of the studied star, also 2 spectra of a hot, rapidly rotating a standard star A2 θ And as a standard for remove telluric lines in the spectrum of HD31648 (Mikailov, Musaev, Alekberov et al., 2020).

The reduction of echelle spectra was carried out according to the standard technique using the recent version of the DECH 30 program developed by Galazutdinov (1992).

3. Results of observations

Emission Hα and Hβ lines in the spectrum of the star HD31648 are formed in the sufficiently extended circumstellar shell and show profiles of type P Cyg, which are direct indicators of mass ejection.

In the spectrums at our disposal, the radial velocities of the Hα and Hβ line components were measured, and their profiles were constructed (Fig. 1).

As it is known, the results of the interaction of a star with its circumstellar matter show itself in the form of an outflow (stellar wind) or star accretion of matter (accretion).

It should be noted that in terms of observational astrophysics, spectral signs of stellar wind and star accretion of matter are shown in the so-called P Cyg and inverse P Cyg profiles, respectively, in certain diagnostic lines.

As can be seen from Fig. 1 the Hα line is predominantly observed as a P Cyg III type profile, characterized by a line intensity ratio of Ib/Ir $\ll$ 1 and in two cases it was observed as a classical P Cyg type profile – a red-shifted emission peak with blue-shifted absorption.

There is no correlation in the changes in the intensity of the blue (Ib) and red (Ir) components. The blue component undergoes the greatest changes, and variability is also present in the intensity of the red emission peak.

The Hβ line profile in the central part shows a P Cyg type structure with wide photospheric wings. The red emission component of the Hβ line shows strong variability, which correlated with the red emission component of the Hα line. In general, variability in the profiles of the Hα and Hβ lines occur synchronously. In the work, a comparative analysis of the behavior of the Hα and Hβ lines is carried out using similar data from published data([Beskrovnaya and Pogodin, 2004, Tambovtseva et al., 2016).

When processing echelle spectra of early spectral type stars, in particular Herbig Ae/Be stars, one of the main difficulties is the determination of the continuum level, due to the broad wings of the hydrogen lines. We constructed a continuum for orders containing the Hα and Hβ lines by interpolating the continua of two adjacent orders. After this procedure, the continuum shape was refined using the spectrum of the standard star obtained under the same conditions. Fig. 2 shows the profiles of the Hα and Hβ lines in the spectrum of HD 31648 and the standard star θ And (sp. A2). As a result, we obtained a close match of the outer part of the wings of the photospheric profiles of Hα and Hβ in the spectra of HD 31648 and the standard star θ And.

The profiles of the Hα and Hβ lines in the spectrum of the star HD 31648 presented in Fig. 1 according to our data in appearance are generally consistent with similar data published in the works (Beskrovnaya and Pogodin, 2004, Tambovtseva et al., 2016).

4. Conclusions

We present preliminary results of observations of the Hα and Hβ lines in the spectrum of the Herbig Ae star HD 31648.

- In the spectra at our disposal, the Hα line is predominantly observed as a P Cyg III type profile, characterized by a line intensity ratio of Ib/Ir $\ll$ 1 and in two cases it was observed as a classical P Cyg type

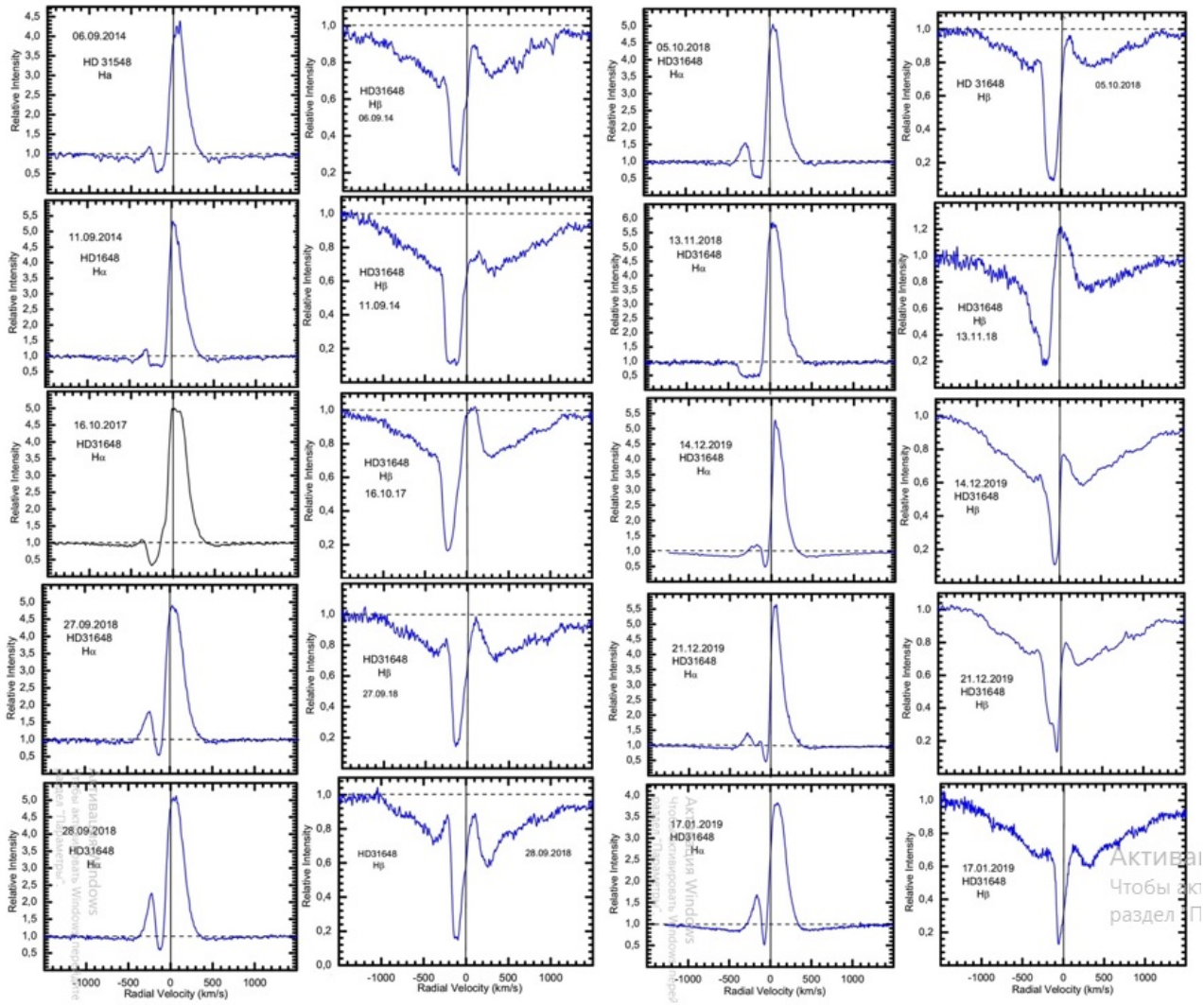

Figure 1: Profiles of the Hα and Hβ lines in the spectrum of HD 31648

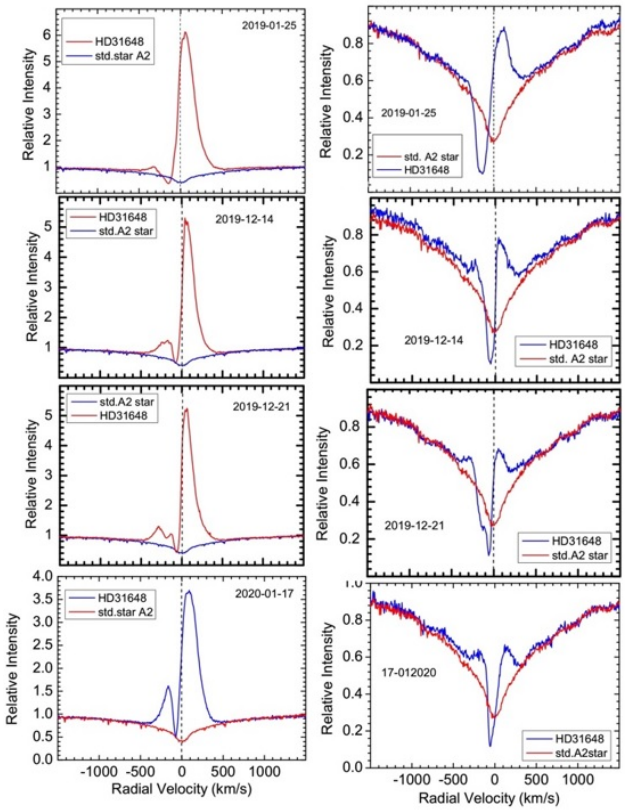

Figure 2: Profiles of the Hα and Hβ lines in the spectrum of HD 31648 and the standard star θAnd (sp. A2)

profile – a red-shifted emission peak with blue-shifted absorption.

• There is no correlation in the changes in intensity of the blue (Ib) and red (Ir) components.
• The blue component undergoes the greatest changes, and variability is also present in the intensity of the red emission peak.
• The Hβ line profile in the central part shows a P Cyg-type structure with wide photospheric wings.
• The red emission component of the Hβ line shows strong variability, which correlated with the red emission component of the Hα line.
• In general, variability in the profiles of the Hα and Hβ lines occur synchronously. In the work, a comparative analysis of the behavior of the Hα and Hβ lines is carried out using similar data from published data.

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