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Spectroscopy of B stars in the very young open star cluster IC 1805

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Abstract. Based on moderate-resolution spectra in the range 4200–5200 Å, we have studied late O and early B stars in the very young open star cluster IC 1805. The temperatures of the stars under the study have been derived by the differential method, in which simple parameters were chosen for a number of spectral lines and were then compared with the analogous parameters from an extensive sample of O–B stars. Accurate $T_{\rm eff}$ estimates have been obtained for them from model atmospheres. Applying this method for the sample of objects under the study has allowed the cluster age $t = 2 \pm 0.5$ Myr and distance modulus $(v–V)_0 = 11\overset{\rm m}{.}5$ to be determined with confidence.

Keywords: stars: spectroscopic observations; open star clusters; age of cluster

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1 Introduction

The very young open star cluster IC 1805 is a part of the OB association Cas OB6 in the Perseus arm and is located within the H II region W4. The cluster has been well-studied photometrically. It was investigated in the UBV system by Massey et al. (1995), etc. and in the medium-band Vilnius system by Straižys et al. (2013). The spectral classification for bright O–B stars has been performed repeatedly. The cluster was shown to be extended and to have a diameter of 20–25 arcmin with a low concentration of stars to the center. The distance to the cluster was estimated from spectroscopic observations to be 1.9–2.4 kpc. Since most of the cluster objects are faint, there are few spectroscopic studies of the physical parameters of stars and they are concentrated mainly on the atmospheres and their nonstationarity in O stars. Most of the authors estimated the age to be 1–6 Myr. This means that only the most massive O stars have left the zero-age main sequence. Therefore, the main goal of this paper was an accurate determination of the temperatures of late O and early B cluster stars, their positions on the main sequence, and, consequently, a refinement of the cluster age by a method different from the photometric one based on spectroscopic observations.

2 Observations and temperature determination

All spectroscopic observations of the OB stars in the cluster IC 1805 were performed with a moderate resolution spectrograph mounted at the Nasmyth focus of the 2.6-m ZTSh telescope at the Crimean Astrophysical Observatory. The spectra were taken in the wavelength range 4200–5200 Å with a resolution of about 1.5 Å and a signal-to-noise ratio, as a rule, better than 100. In total, we took the spectra for 24 cluster O and B stars. In addition, we took the spectra for more than 30 B stars from the list by Lyubimkov et al. (2000, 2002) with the same instrumental settings, for which their atmospheric parameters were determined with a high accuracy. These spectra were subsequently used to determine the effective temperature $T_{\rm eff}$ for the cluster B stars.

We used the differential method to determine the effective temperatures $T_{\rm eff}$ of the late O and B stars in the cluster. Since the cluster age is known approximately and, according to various estimates, lies within the range 1–6 Myr, it is reasonable to assume that all B stars of the spectral types B0–B6 are normal dwarfs. Hence, we took the spectra of more than 30 stars from the list by Lyubimkov et al. (2000, 2002) satisfying this criterion with the same instrumental settings of the spectrograph as those used in the observations of cluster stars.

To determine the temperature, we chose the following parameters of the spectra: the ratio of the residual line fluxes $F(\mathrm{He\,I}\,4471)/F(\mathrm{Mg\,II}\,4481)$; the equivalent widths W_λ of the Hβ and Hγ lines; the residual fluxes of metal lines, several He I and He II lines. The criteria chosen to determine $T_{\rm eff}$ have different sensitivities, depending on the stellar temperature. As an example, Fig. 1a, b present the derived dependences to determine the temperature from the parameters $F(\mathrm{He\,I}\,4471)/F(\mathrm{Mg\,II}\,4481)$ and $W_\lambda(\mathrm{H}\gamma)$. According to the set of criteria listed above, the errors in $T_{\rm eff}$ for non-emission-line OB stars did not exceed 500°.

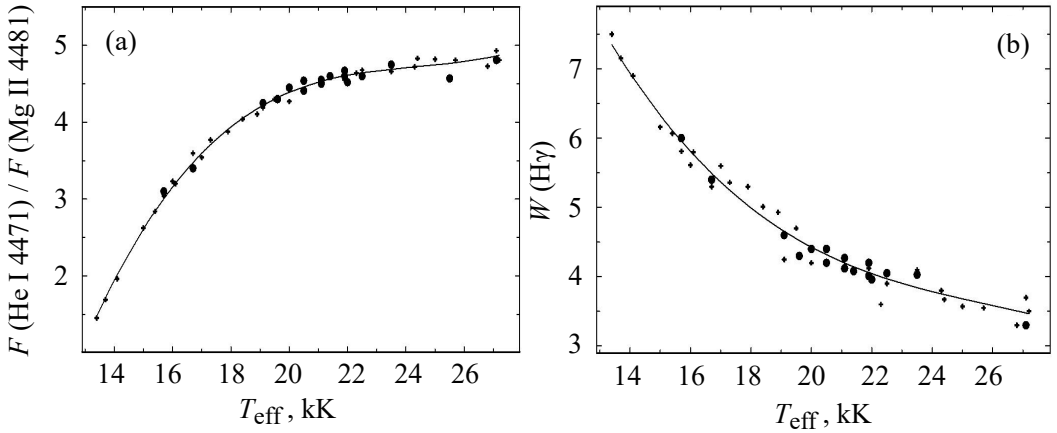

Fig. 1. Examples of the dependences used to determine $T_{\rm eff}$ from the observed line parameters, $F(\mathrm{He\,I}\,4471)/F(\mathrm{Mg\,II}\,4481)$ (a) and $W_\lambda(\mathrm{H}\gamma)$ (b). The crosses mark the parameters of the standard stars from the list by Lyubimkov et al. (2000, 2002) obtained in this paper with the same instrumental settings as those for the objects under the study; the solid curve indicates the polynomial dependence constructed from these data; the filled circles indicate the temperatures of the stars under the study estimated from the set of several criteria whose list is given in the text.

3 The cluster age

The cluster IC 1805 is fairly remote and located at the edge of the Perseus arm on the inside. There are relatively few background stars of this arm in this direction, but a noticeable number of Orion arm stars are present, as confirmed by detailed medium band photometric studies in the visible and near infrared ranges (Straižys et al. 2013). To determine the cluster age, we used the V-band observations taken from the WEBDA database and the values of $T_{\rm eff}$ determined above. The interstellar extinction A_V toward the cluster was studied in detail by Straižys et al. (2013) and is about $2\overset{\mathrm{m}}{.}5$.

4 Conclusion

The obtained results were presented in Fig. 2. As follows from the figure, we managed to estimate the cluster age with confidence using the $T_{\rm eff}$ as a parameter independent of photometric observations. The isochrone shown in the figure was constructed from the evolutionary models of Bressan et al. (2012) for solar metallicity. The best agreement of the observational data with the theoretical calculations was achieved for the cluster age $t = 2.0 \pm 0.5$ Myr and distance modulus $(v–V)_0 = 11\overset{\rm m}{.}5$.

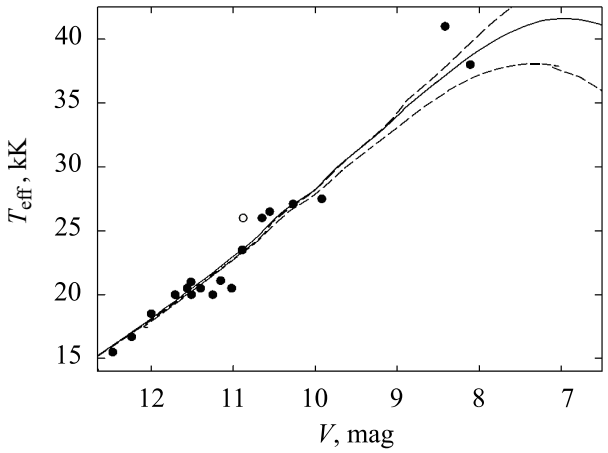

Fig. 2. The $T_{\rm eff}$–V diagram constructed from the stars in the cluster IC 1805. The filled circles indicate the OB stars; the open circle indicates the Be star MWC 50. The solid curve is the isochrone constructed for a cluster with an age $t = 2$ Myr, metallicity Z = 0.02, and distance modulus $(v–V)_0 = 11\overset{\rm m}{.}5$. The isochrones marked by the dashed lines correspond to the age of 1 Myr and 3 Myr respectively.

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