A spectroscopic investigation of the young open cluster IC 1805*

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Abstract: We present the main results of a spectroscopic campaign devoted to the O-type stars in the young open cluster IC 1805. This study aims at the investigation of the multiplicity and the line profile variability of its brightest massive members. We present new results concerning the line profile variability of He II λ 4686 and Hβ for HD 15570 and HD 15629. For these two stars, our radial velocity analysis does not reveal any variations compatible with a binary motion. We also significantly improve the orbital parameters of the long period binary HD 15558. For this latter system, we present for the first time evidence for the detection of the secondary, leading to spectral types of O5.5 and O7 respectively for the two components.

1 Introduction

IC 1805 contains 10 O-type stars, among which some of the most luminous and most massive early-type stars of the Galaxy. It is also supposed to harbour an unidentified EGRET gamma-ray source, whose relation to O-type stars is not excluded. Moreover, it contains the non-thermal radio emitter HD 15558, and constitutes therefore an interesting target for the investigation of the non-thermal emission from massive stars. This cluster was also proposed to be characterized by a very high binary fraction among its O-star members ($\sim 80\,\%$).

2 Data description

Spectra were obtained in the blue domain (4450 - 4900 Å) with the Aurélie spectrograph mounted on the T152 telescope at the Observatoire de Haute-Provence (OHP, France), for the 6 brightest O-stars of the cluster: HD 15558, HD 15570, HD 15629, BD+60° 497, BD+60° 501 and BD+60° 513 (see Rauw & De Becker 2004 for a study of the latter three targets). A more intense monitoring of HD 15558 was performed with the Elodie echelle spectrograph mounted on the T193 telescope at OHP. The aim of this study was to investigate the multiplicity of the O-stars of the cluster, along with their line profile variability and relate it to the various possible scenarios.

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3 Main results

In this section, we briefly describe the main results of our optical campaign devoted to the most massive members of IC 1805, namely HD 15558, HD 15570 and HD 15629. In Fig. 1, we present the blue spectrum obtained with the Aurélie spectrograph for the three stars.

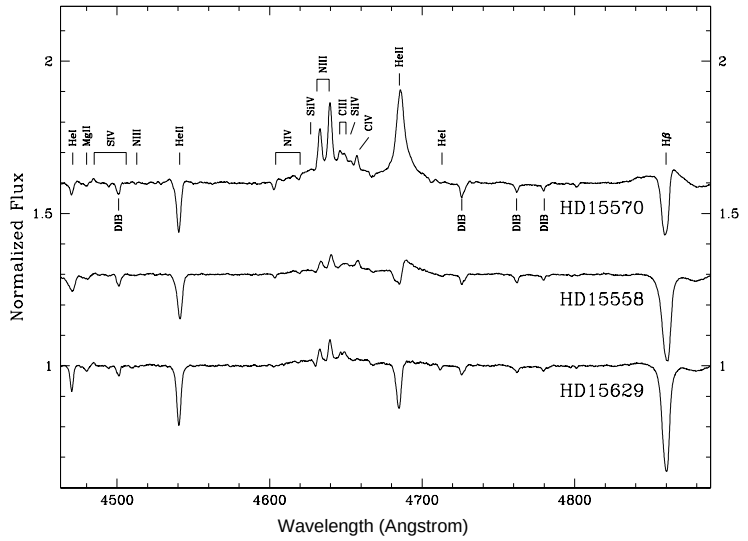

Figure 1: Optical spectra obtained in the blue domain for the three brightest O-stars of IC 1805. HD 15570: the main feature is the strong He II λ 4686 emission, along with the strong N III $\lambda\lambda$ 4639-4641 lines. Hβ is in P-Cygni. HD 15558: the emission lines are weaker, and He II λ 4686 displays a P-Cygni profile. HD 15629: the spectrum is typical of a single O5 main sequence star.

3.1 HD 15570

Our investigation of the radial velocity of HD 15570 (O4If$^+$) did not reveal any significant variations attributable to binarity on time-scales of a few days, or from one year to the next. However, we observed a significant line profile variability of He II λ 4686 and Hβ (see Fig. 2), with a recurrence time-scale of about 6 days. The equivalent width of He II λ 4686 presents a somewhat marginal modulation probably with a time-scale of about 6 days, but we note that this time scale is not very well defined.

Two scenarios could be envisaged to explain these profile variations:

- The variations could possibly be attributed to rotational modulations, the time-scale of 6 days being the rotational period.

- Another possibility to be considered is a wind-wind interaction within a binary system seen under a low inclination, but if the rotational and orbital axes are parallel this would lead to an excessive V_{rot} ($V_{rot} \sin i = 130\,\mathrm{km\,s^{-1}}$). For this reason, the rotational modulation scenario is slightly preferred (for details, see De Becker et al. 2005).

3.2 HD 15629

For this O5V((f)) star, our investigation did not reveal any significant radial velocity variation attributable to a binary motion on time-scales of a few days, or from one year to the next. However, we detected a significant variability of the profile of the He II λ 4686 and Hβ lines with a time-scale of a few days. We note that this variability is clearly detected during one observing run (September 2002) whilst it is marginal in other data sets. This suggests possible transient variations that require further investigation with more data (see De Becker et al. 2005).

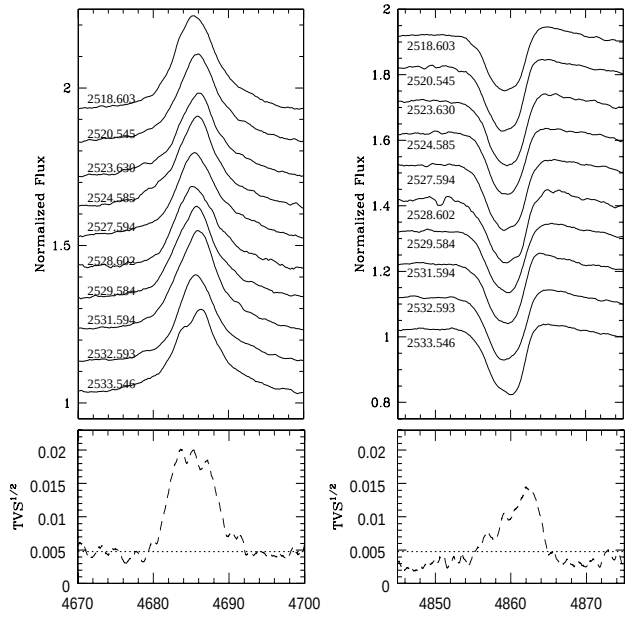

Figure 2: Line profile variability of He II λ 4686 (left) and Hβ (right) for HD 15570. The upper panels show the line profiles obtained with Aurélie in September 2002. The heliocentric Julian dates (- 2 450 000) are specified in each case. The profiles present correlated variations suggesting that more than one component contribute to the lines. In the lower panels, the Time Variance Spectra (TVS, see Fullerton et al. 1996) show variability levels well above the 90 % confidence threshold. For He II λ 4686, the variability is very high for the entire line. For Hβ, the variations are more significant in the emission part of the P-Cygni profile.

Table 1: Orbital parameters of HD 15558 determined from our times series obtained at OHP.

P	442 ± 12 d	K	40.9 ± 1.8 km s^{-1}
e	0.39 ± 0.03	ω	$116° \pm 6°$
T_o	$2\,451\,795.400 \pm 6.556$	a sin i	350.0 ± 15.2 R$_\odot$
γ	-50.2 ± 1.1 km s^{-1}	f(m)	3.0 ± 0.4 M$_\odot$

3.3 HD 15558

On the basis of 70 radial velocity measurements on the He II λ 4542 and N III $\lambda\lambda$ 4634,4641 lines spread over about 1600 days, we obtained a new SB1 solution (see Table 1).

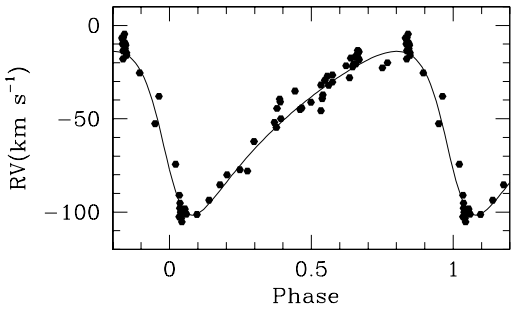

Figure 3: Radial velocity curve of HD 15558 for an SB1 orbital solution with a period of about 442 d. The data points are overplotted. Phase 0 corresponds to periastron.

As the profiles from the two stars are strongly blended at most of the phases, a disentangling method is needed to obtain an SB2 solution. However, we were able to separate to first order the profiles of the primary and of the secondary at phases close to the extrema of Fig. 3. Figure 4 presents the results obtained by fitting Gaussians to the profiles. From this approach, we determined the He I λ 4471/He II λ 4542 equivalent width ratio and hence the spectral types of the two stars, i.e. O5.5 and O7. A disentangling method is also needed to definitely determine the luminosity classes, but we tentatively propose they may be III and V respectively for the primary and the secondary. We note also that the He II λ 4686 P-Cygni profile of the primary

presents a significant variability on a time-scale of a few days, possibly attributable to rotational modulations (see De Becker & Rauw 2005).

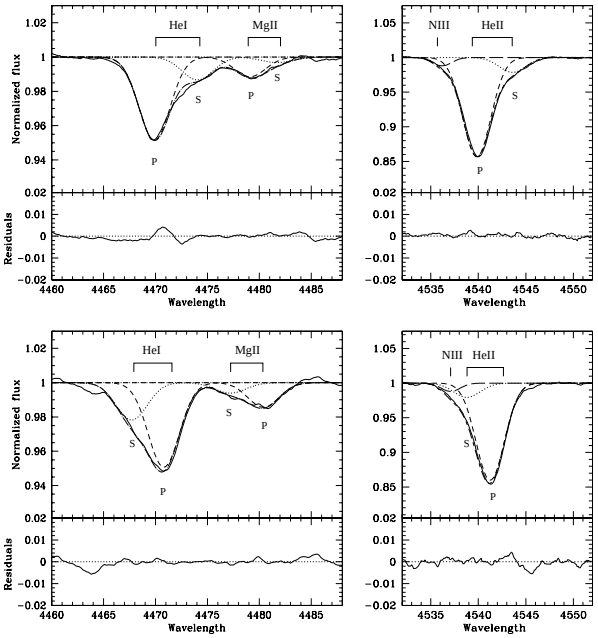

Figure 4: Simultaneous fit of Gaussians to the profiles of the He I λ 4471 , Mg II λ 4482 and He II λ 4542 lines of HD 15558. Upper part: phase $\sim$0.05. Lower part: phase $\sim$0.85. The P and S symbols stand respectively for the primary and secondary components of each line.

4 Summary and conclusions

Our radial velocity study did not reveal any significant variations for HD 15570 and HD 15629 on time scales of a few days or from one year to the next. This strongly supports the single star scenario for both stars. Both stars present significant profile variations of the He II λ 4686 and Hβ lines. For HD 15570, the recurrence time-scale is of about 6 d, and it might be attributed to rotational modulations. For HD 15629, the variability is mostly observed in only one data set, suggesting it might be transient. In the case of HD 15558, our intensive campaign led to the determination of a new orbital solution, based on a homogeneous set of spectral lines. For the first time, the companion is detected and we propose O5.5III and O7V spectral types respectively for the primary and the secondary.

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