

Multiplicity of O-type stars in NGC 2244

L.Mahy⁽¹⁾, Y. Nazé⁽¹⁾, G. Rauw⁽¹⁾, E. Gosset⁽¹⁾, M. De Becker⁽¹⁾, P. Eenens⁽²⁾ & H. Sana⁽³⁾



⁽¹⁾Institut d'Astrophysique et de Géophysique de l'Université de Liège, Belgium

⁽²⁾Departamento de Astronomía, Universidad de Guanajuato, Guanajuato, Mexico

⁽³⁾European Southern Observatory, Santiago, Chile



Abstract:

We present the main results from our long-term spectroscopic campaign devoted to the O-type stars in the young open cluster NGC 2244. Previous works by our team on the O-stars multiplicity in other young open clusters (IC 1805 and NGC 6231) showed that the number of binary systems in such clusters was larger than 40%. Until now, only two stars (HD 47129 and HD 48099) in the surroundings of NGC 2244 have been confirmed as spectroscopic binaries (SB) although Garcia & Mermilliod (2001) estimated the O-type binary fraction at 50%. In this context, we revisited the spectral classification, the projected rotational velocity and the multiplicity of O-type stars in NGC 2244.

Rapid Rotators:

- **HD 46056:** the star shows very broad and shallow line profiles (Fig. 1). They display some variations but cannot easily be associated with a second component. It could be either an effect intrinsic to the stellar atmosphere, or due to pulsations.

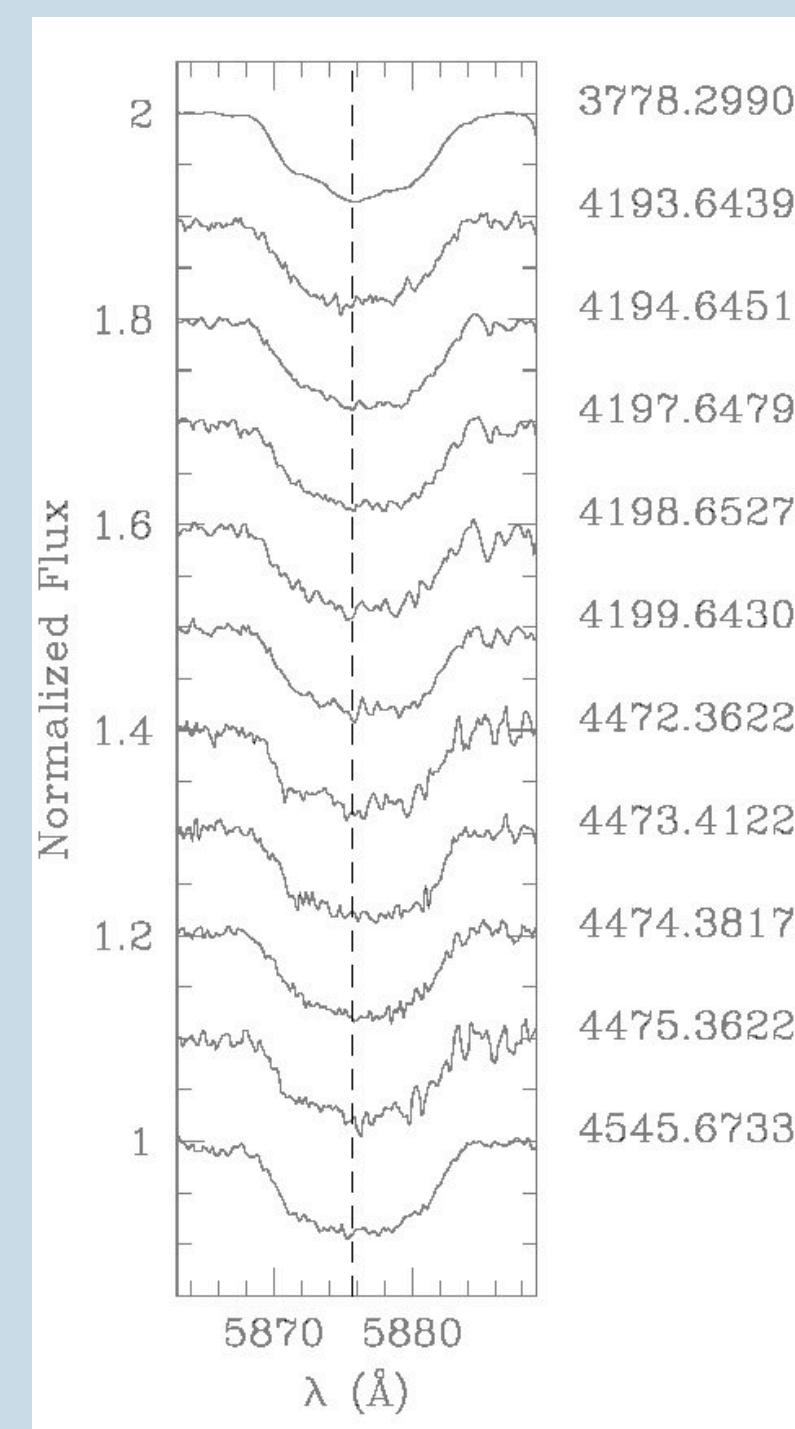
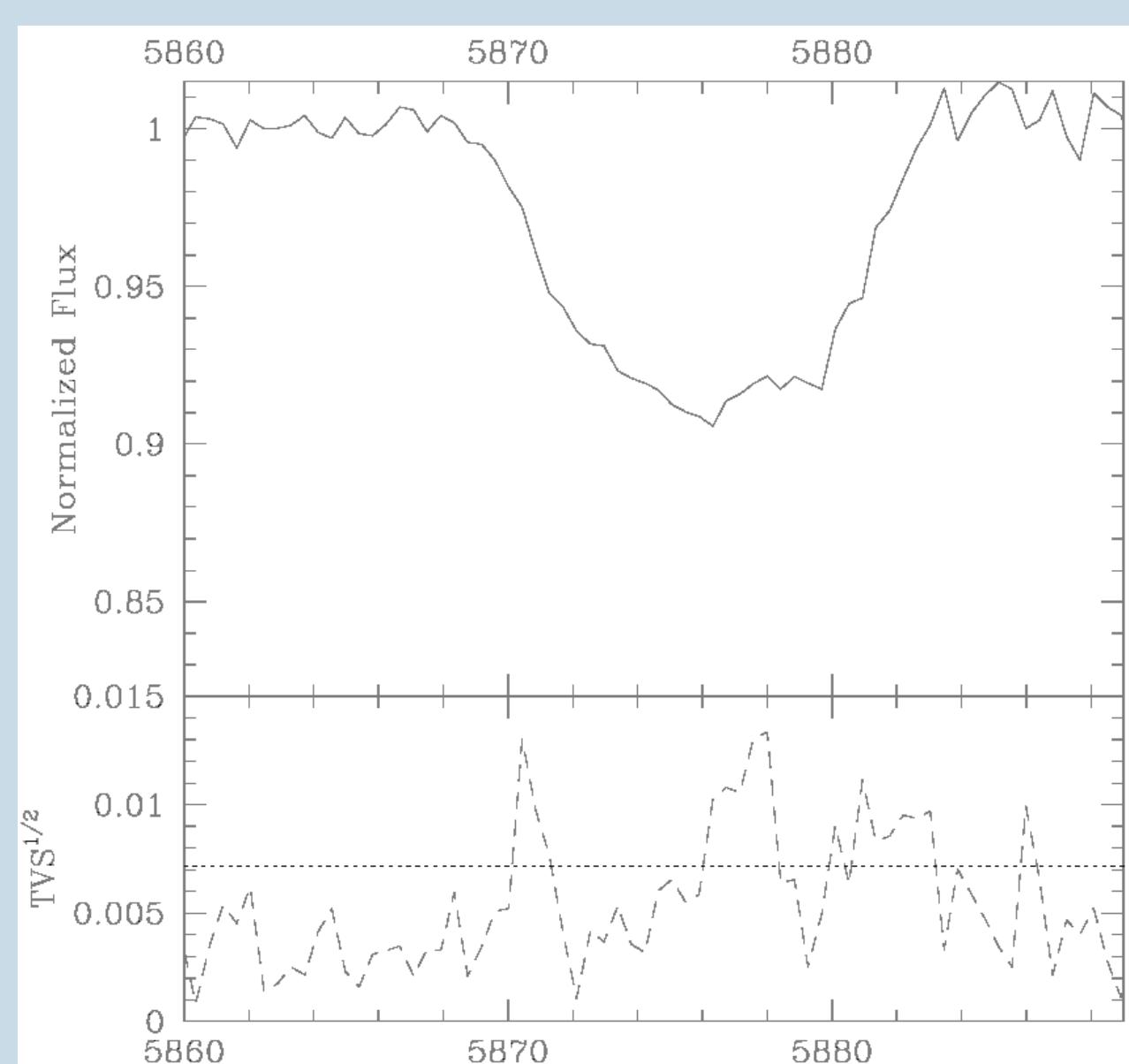


Fig. 1: He I λ 5876 line profile. HJD is given in HJD–2 450 000. All spectra are displayed in the heliocentric frame of reference. The vertical dashed line represents the rest wavelength.



- **HD 46485:** The Temporal Variance Spectrum (TVS; Fullerton et al. 1996) shows variations but does not exhibit the double peak structures, typical of SB (Fig. 2).

Fig. 2: Mean spectrum and TVS of HD 46485 for He I λ 5876. The observed variations are barely significant, and do not display a typical double peak structure.

Star	O III λ 5592	C IV λ 5801	C IV λ 5812	He I λ 5875	Na I λ 5890	Na I λ 5896
HD 46056	—	—	—	27.7 ± 7.6	23.6 ± 2.1	24.7 ± 2.4
HD 46149	11.4 ± 22.4	23.0 ± 21.8	19.5 ± 20.6	21.0 ± 20.0	21.1 ± 3.3	21.8 ± 3.4
HD 46150	26.4 ± 8.1	48.0 ± 12.0	33.4 ± 13.1	32.2 ± 5.7	20.7 ± 2.3	21.0 ± 2.3
HD 46202	31.4 ± 1.9	39.7 ± 3.1	35.5 ± 2.8	39.5 ± 2.2	23.0 ± 1.9	23.8 ± 2.1
HD 46223	30.9 ± 7.3	50.7 ± 2.9	38.4 ± 6.3	35.4 ± 2.8	22.7 ± 2.4	23.1 ± 2.3
HD 46485	—	—	—	40.2 ± 12.7	22.0 ± 3.4	22.4 ± 4.2

Tab. 1: Mean radial velocities and 1- σ dispersion. The data are expressed in km s⁻¹.

Spectroscopic Binary & Variable star:

- **HD 46149:** No short-term line profile variation was observed but spectra showed large RV changes on 1 year time scales, implying that HD 46149 is a spectroscopic binary. We detected the secondary component and we found a mass ratio of about 0.5.

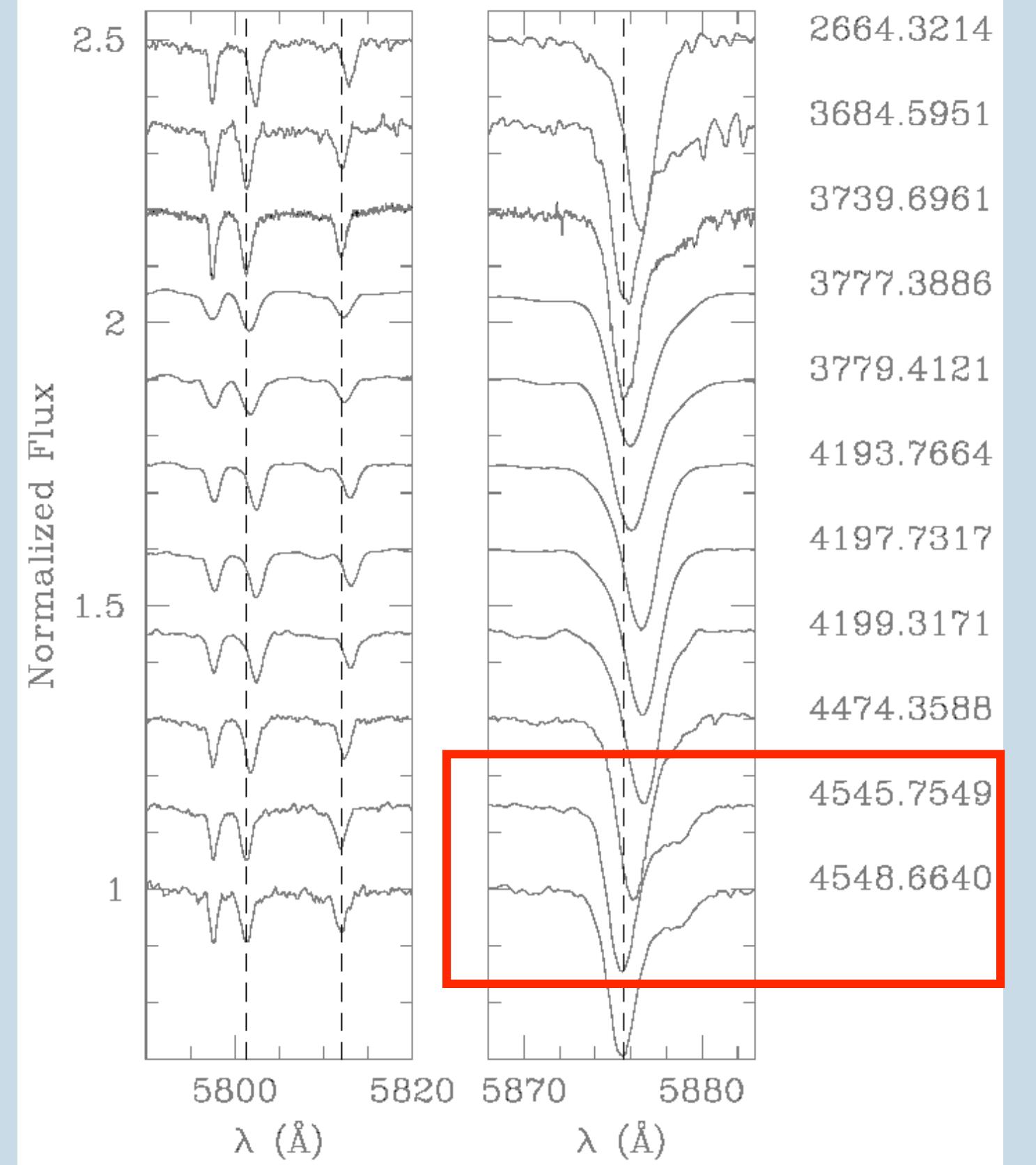


Fig 4: C IV $\lambda\lambda$ 5801-12 and He I λ 5876 line profile. The signature of the secondary is clearly seen in the red box.

- **HD 46150:** The TVS shows double and triple peak structures, typical of an SB (Fig. 5). Significant RV variations are detected, but no companion, suggesting that this star is a binary candidate.

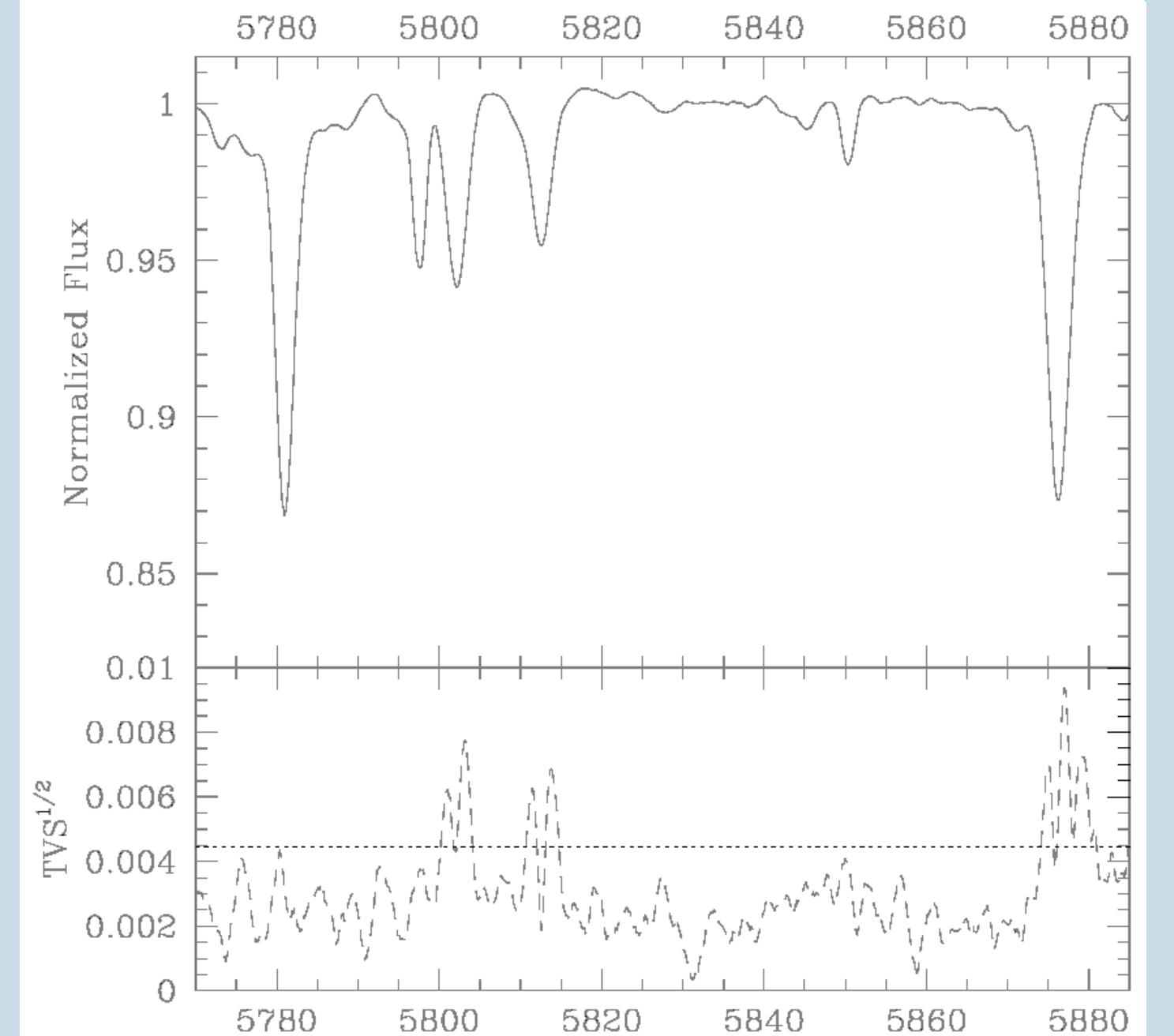


Fig. 5: Mean spectrum and TVS of HD 46150 for the C IV $\lambda\lambda$ 5801-12 and He I λ 5876 lines

Presumably single stars:

- **HD 46202:** The RV dispersions (Tab. 1) are similar for the stellar and for the interstellar lines during our 2 year spectroscopic campaign.

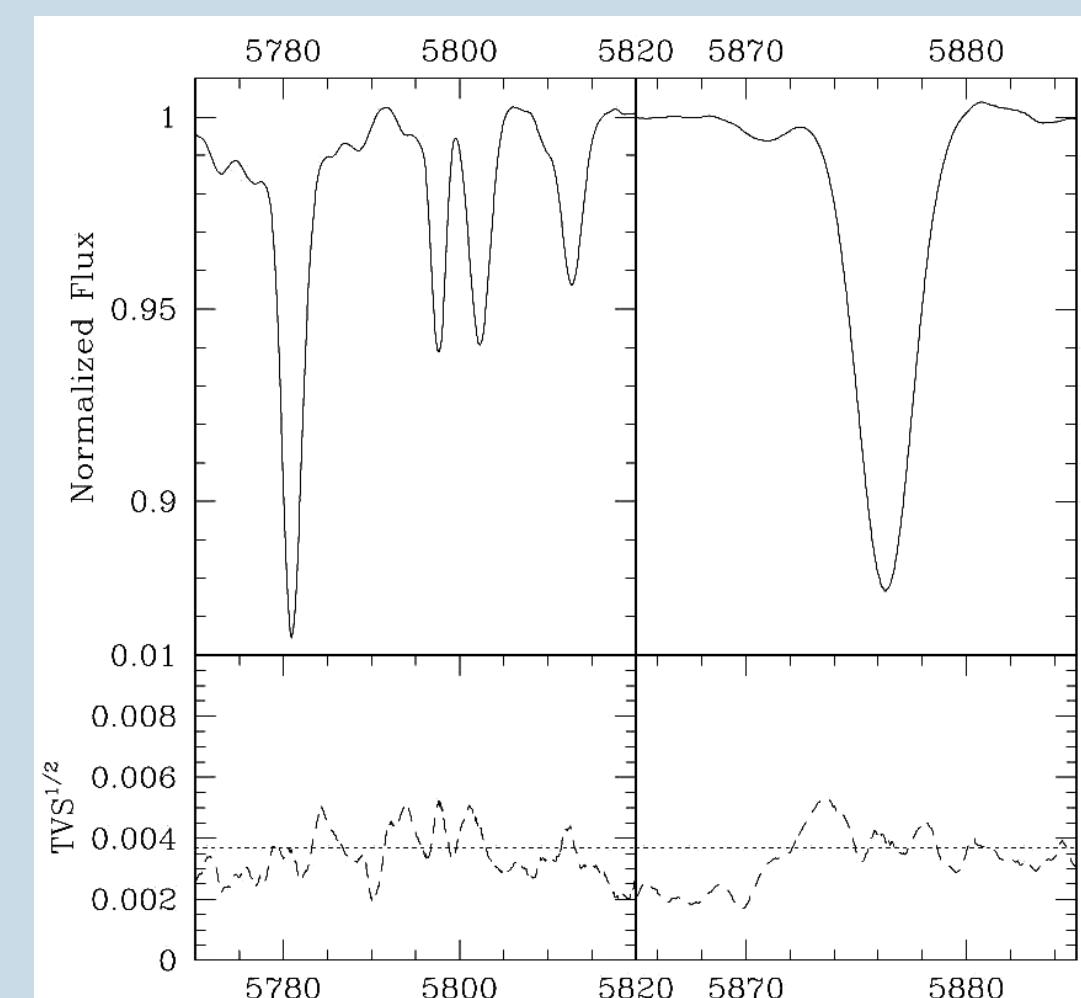


Fig. 3: Mean spectrum and TVS of HD 46223 for the C IV $\lambda\lambda$ 5801-12 (on the left) and He I λ 5876 lines (on the right).

Conclusions:

The binary fraction of O-stars in NGC 2244 had been previously estimated at 50% (García & Mermilliod, 2001).

Our investigations (Tab. 2) show that this value has been overestimated and revealed only 1 (maybe 2) long period system. No short period binary and no binary system with similar components (i.e. mass ratio near unity) were detected in NGC 2244. These results imply a minimum binary fraction of 17%.

The proportion of (short period) O+O and O+B binaries (Tab. 3) in NGC 2244 and in IC 1805 is smaller than in other clusters such as NGC 6231.

These different results allow us to confirm the hypothesis of a correlation between the density of the cluster and the massive star binary fraction, already proposed by García & Mermilliod (2001).

These 3 different clusters will help constrain theoretical models describing the formation and evolution of early-type stars.

Name	Spectral Type	$v \sin i$	Spectroscopic status
HD 46056	O8Vn	365 ± 21	rapid rotator (intrins. var)
HD 46149	O8V+B1–2V:	78 ± 11 [‡]	SB2
HD 46150	O5.5V(f)	97 ± 9	Bin?
HD 46202	O9V	41 ± 9	C
HD 46223	O4V(f*)	100 ± 17	C
HD 46485	O8Vn	301 ± 25	rapid rotator (intrins. var)

[‡] Notes: The reported value for HD 46149 is the projected rotational velocity for the primary.

Tab. 2: Summary of the optical properties of O-type stars in NGC 2244. The last column reports the status of the star: « Bin? » for a potential binary; « C » suggests that the star is single; « SB2 » for a spectroscopic binary where the two components are visible.

References:

- De Becker, M., Rauw, G., Manfroid, J. & Eenens, P. 2006, A&A, 456, 1121.
 Fullerton, A. W., Gies, D.R., & Bolton, C.T. 1996, ApJS, 103, 475.
 Garcia, B., & Mermilliod, J. C. 2001, A&A, 368, 122.
 Rauw, G., & De Becker, M. 2004, A&A, 421, 693.
 Sana, H., Gosset, E., Nazé, Y., Rauw, G., & Linder, N. 2008, MNRAS, 386, 447.

* Notes: NGC 6231 also contains a WR+O binary but, in our table, we only focus on O-stars.

Tab. 3: Summary of the multiplicity in young open clusters. The columns 3–6 give the number of O-stars in each cluster, the number of detected short and long period binaries and the variable stars (potential binaries and probable intrinsic variables).