The O stars sample of the Tarantula-FLAMES survey

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Science Drivers

This ESO programme was developed in order to provide a large amount of data from massive OB stars across the 30 Doradus region (LMC). More than 1000 spectra were obtained with the FLAMES multi-object spectrograph at VLT (Paranal, Chile). It is a continuation of our first project[1]. The FLAMES Massive Star Survey (Evans et al., 2005). In that project we showed that not all chemical mixing can be explained by stellar rotation. In the present project, besides rotation, we want to explore the role of binarity and variability in the stellar evolution and the ISM enrichment by winds.

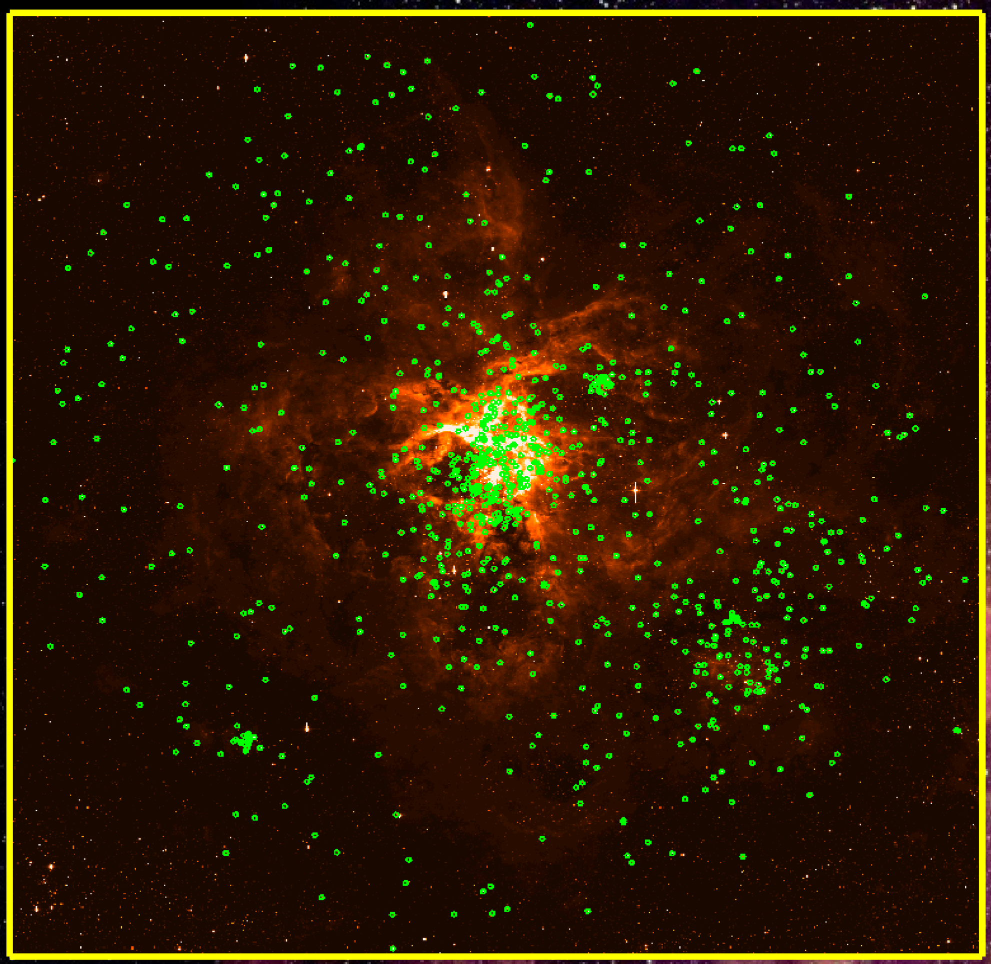

Figure 1: The 30 Doradus region. The green circles are the target stars of the Tarantula-FLAMES survey[3],[5]..

The O-stars subsample: quantitative analysis with FASTWIND

As a first step we chose three of the large sample of OB stars. Our main criteria were high SNR and clearly visible spectral lines. We studied an early, a mid and a late-type O star. For each star, the individual spectra were added to obtain a higher SNR spectrum.

The goal of this work was to obtain the main physical parameters that characterize massive stars with winds by comparing the observed spectra with those theoretically calculated by means of NLTE model atmospheres. This task was carried out with the FASTWIND[2] code (Puls et al., 2005). We used a grid of NLTE, line-blanketed model atmospheres calculated for O-type stars in the LMC. It doesn't take into account the effects of wind clumping.

The physical parameters that define each model are: effective temperature, gravity, Q, β (velocity law exponent), Helium abundance, rotational velocity and microturbulence. We assumed a metalicity of Z=0.40. We selected the models that fitted best H and He lines of the spectra. Hydrogen Balmer series, HeI4387, HeI4922, HeI5015, HeI5047, HeI4471, HeI5875, HeII4200, HeII4541, HeII4686, HeII5411 and HeI6678+HeII6683.

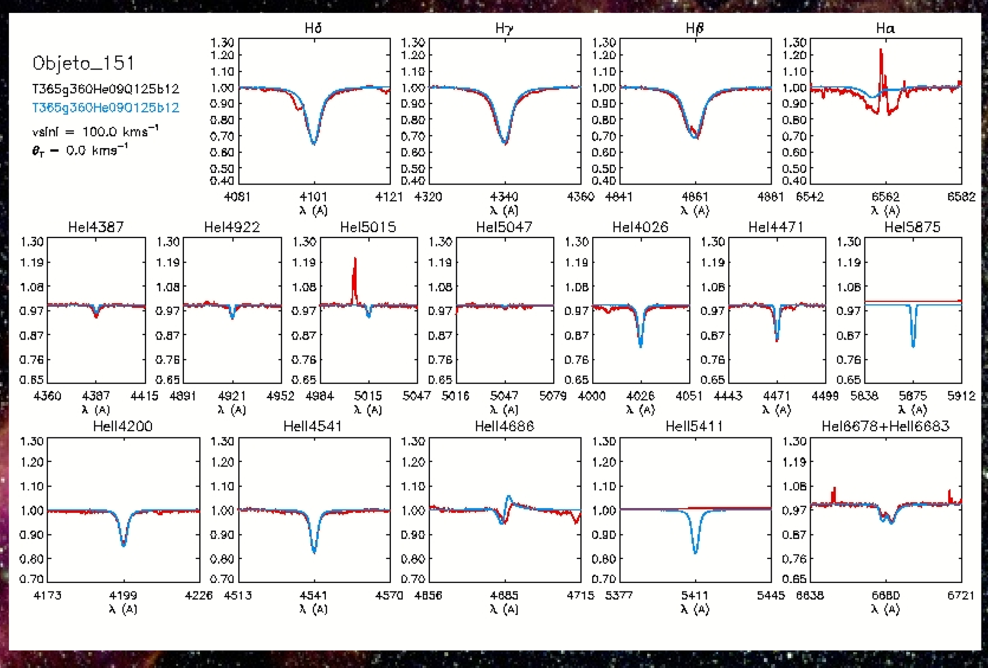

Figure 3: Example of analysis with FASTWIND. The lines belong to a mid O star in 30 Doradus.

Balmer lines broadening is used for estimating gravity because these lines become broader as gravity increases. On the other hand, wind parameters (β, Q) are mainly determined using Hα and HeII4686, due to the fact that these lines are very sensitive to wind effects.

The problem of T_{eff} in early O stars

The comparison between HeI and HeII lines is a good indicator to determine effective temperatures for late and mid type stars, because both lines, HeI4471 and HeII4541, are perfectly visible, so we can use the ionisation balance to make an estimation of T_{eff}. On the other hand, this method is not valid for very early type stars[6]. In these cases, HeI4471 is not visible anymore, so we cannot calculate the HeI/HeII ratio, and we have to use other lines in the spectrum: nitrogen lines. The nitrogen lines (NII4630, NIII4641, NIV4058, NV4603) ratios will allow us to calculate a more accurate value of T_{eff} for these early stars and also nitrogen abundances in the future.

Star 764 (late)

Star 151 (mid)

Star 180 (early)

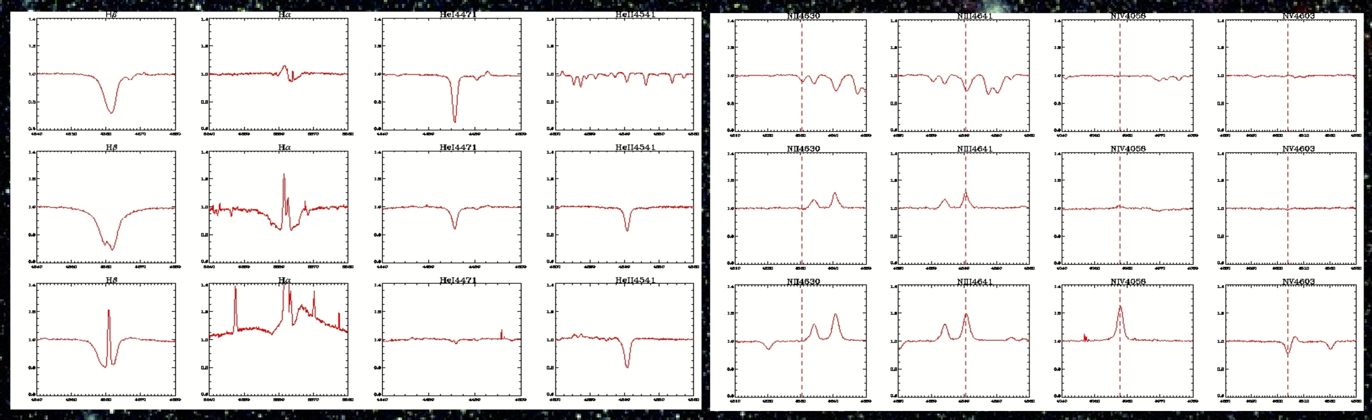

Figure 2: The most important spectral lines used to determine stellar parameters. As we can see, HeI4471 dissapears for earlier objects, so it is impossible to calculate T_{eff} by means of HeI/HeII ionization balance. It becomes necessary to study nitrogen lines.

Observations

Almost 900 spectra of the 1000 stars observed with the MEDUSA fibres[4] were available for this project. The others were rejected because they were cool-type stars or they had poor SNR. The spectra were corrected taking into account the Earth's motion around the Sun (heliocentric frame). Three grating and wavelength modes were used (LR02, LR03 and HR15N), with the following characteristics:

FLAMES mode	Wavelength range (Å)	Resolution
LR02	3964-4567	Low (6400)
LR03	4501-5078	Low (7500)
HR15N	6470-6790	High (17000)

Table 1: Wavelentgh modes that were utilized for the observations.

They were observed in different blocks (multi-epoch spectroscopy), which makes possible to identify binarity and variability, so finally we had 4 to 15 spectra for each wavelength mode and each star.

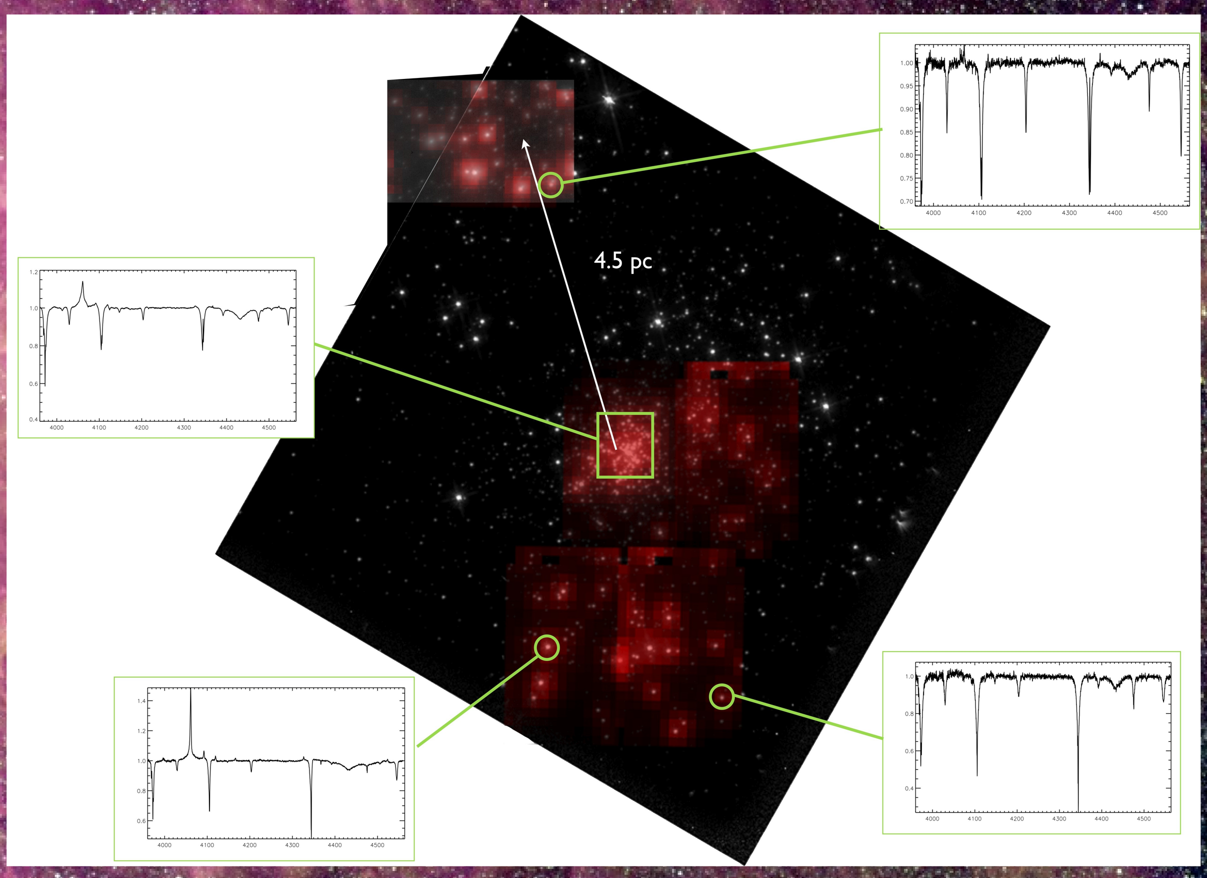

Figure 2: Some additional regions of 30 Doradus were observed with a different mode of FLAMES called ARGUS Integral Field Unit[3],[4].

Results and future work

In the following table we present the resulting stellar parameters obtained by means of model atmospheres calculated with the FASTWIND code:

Object number:	180 (early)	151 (mid)	764 (late)
T_{eff} (K)	55000	36500	28000
Log g	4.00	3.60	3.00
ε = He/(H+He)	0.17	0.09	0.17
Log Q	-11.9	-12.5	-12.3
β	1.2	1.2	0.8
v_{rad} (km/s)	305	290	270
v_{rot} (km/s)	95	100	90
Microturbulence	5	5	5

Table 2: Physical properties of the three O stars belonging to our subsample.

The values of T_{eff} agree with the initial spectral classification of our subsample. If we have a look at effective temperatures, we notice that the early star has a very high value, so we can state that there are very hot stars in the 30 Doradus region.

On the other hand, an outstanding fact is the helium overabundance, with values of 0.17 in both early and late stars, so they may have suffered intense chemical mixing in spite of their youth.

In the future we are going to make the most of the large amount of data by extending the sample up to almost 140 O-type stars, and determining other important physical parameters such as stellar radii and masses.

References

[1]Evans, C.J. et al., 2005, *The VLT-FLAMES Tarantula Survey*

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[3]Lennon, D.J. Et al., 2010, IAU Symposium, 272:*The VLT-FLAMES Survey of Massive Stars*

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[5]Taylor, W. et al., 2010, Liège International Astrophysical Colloquium: *VLT-FLAMES Tarantula Survey of Massive Stars*

[6]Lefever, K., Puls, J., Aerts, C. 2007, ASP Conf. Ser. 999: *The future of photometric, spetrophotometric and polarimetric standarization*

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