MGB and the new GOSSS spectral classification standard grid

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What is GOSSS?

- Galactic O-Star Spectroscopic Survey: Maíz Apellániz et al. (2011).
- We observe all Galactic stars that anybody has ever classified as O (if we get time on a large enough telescope).
- $R \sim 2500$ spectroscopy in the blue-violet region.
- S/N $\sim$ 300 (in $\sim$90% of the cases).
- Telescopes used so far: 1.5 m OSN, 3.5 m CAHA, WHT, and GTC (north); 2.5 m LCO and Gemini (south).
- 2000+ stars observed so far, complete to $B = 8$ ($B = 10$ by 2015), objects as dim as $B = 16$ observed ($B = 19$ planned).
- Limited multiple epochs in some cases for extreme SB2s and variables.
- Devoted pipeline and quality control.

GOSSS goals

- Primary: Spectral classification.
  - Identify and classify all optically accessible Galactic O stars.
  - Improve classification criteria and possibly define new special types.
  - Identify objects wrongly classified as O.
- Secondary:
  - Derive physical properties of O stars.
  - Study SB2s in collaboration with high-resolution sister surveys (OWN, CAFÉ-BEANS, IACOB, and NoMaDS, talks by I. Negueruela and S. Simón-Díaz).
  - The extinction law and the ISM (talk by J. Maíz Apellániz).
  - The spatial distribution of massive stars and dust.
  - The massive-star IMF.

MGB

- A code that attacks spectral classification: Maíz Apellániz et al. (2012).
- Classical visual (non-automatic) spectral classification by interactively comparing with a standard grid.
- Four parameters:
  - Spectral subtype (horizontal classification).
  - Luminosity class (vertical classification).
  - n index (broadening).
  - Alternative standards at each grid point (e.g. ONC or f variants).
- It includes fitting of SB2 systems (Figure 1).
- Default grid: O2-O9.7 from GOSSS (see below).
- Other grids (O-type or other) at various resolutions using the original or degraded spectra from different on-going high-resolution surveys (e.g. IACOB, OWN, IACOBsweG).
- MGB v1.0 available now from `http://jmaiz.iaa.es`

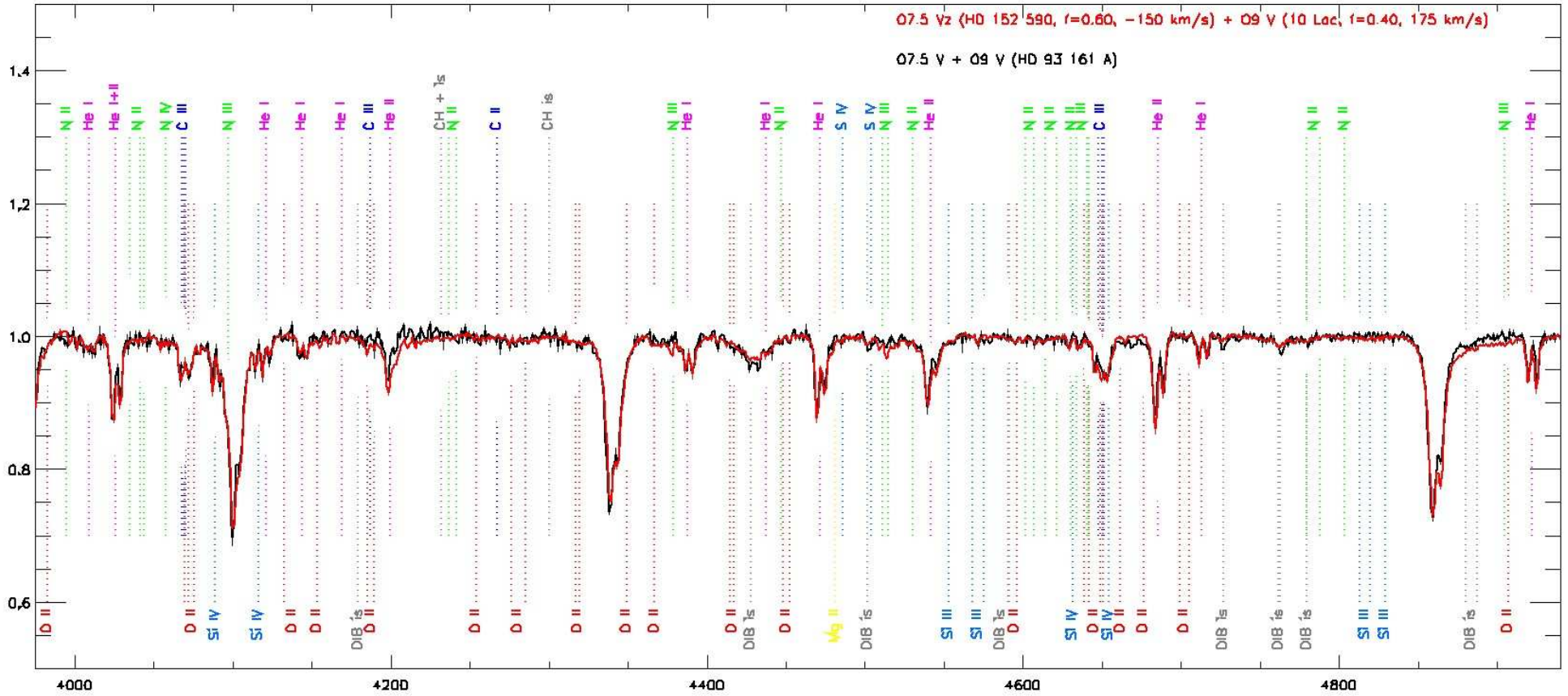

Figure 1. Example of fitting an SB2 system with MGB. Eight parameters can be adjusted: the spectral subtypes, luminosity classes, and velocities of both the primary and secondary, the flux fraction of the secondary, and the rotation index n. Here HD 93 161 A (black) is fitted with a combination (red) of 60% of HD 152 590 and 40% of 10 Lac separated by 325 km/s.

The new GOSSS standard grid

- OB2500 v2.0 grid: integrated with MGB.
- It covers spectral subtypes from O2 to O9.7 and luminosity classes from V to Ia (Table 1).
- Two types of gaps: non-existing types (blank) and standards not yet found (. . .).
- Similar to OB2500 v1.0, the grid in Sota et al. (2011), but with small changes introduced by Sota et al. (2014) e.g. the addition of O9.2 and new standards.
- Available from `http://jmaiz.iaa.es` with MGB v1.0.
- Future extension to A0 (including all B stars) and luminosity class Ia+.

	V	IV	III	II	Ib	Iab/I	Ia
O2						*HD 93 129 AaAb*	
O3	*HD 64 568*		···			Cyg OB2-7	
O3.5	*HD 93 128*		*Pismis 24-17*			···	
O4	**HD 46 223** *HD 96 715*		**HD 168 076 AB** *HD 93 250 AB*			HD 15 570 HD 16 691 HD 190 429 A	
O4.5	HD 15 629 *HDE 303 308 AB*		···			HD 14 947 Cyg OB2-9	
O5	*HDE 319 699* **HD 46 150**		**HD 168 112** *HD 93 843*			*CPD -47 2963*	
O5.5	*HD 93 204*		···			Cyg OB2-11 *ALS 18 747*	
O6	*CPD -59 2600* HD 42 088 *HDE 303 311*	*HD 101 190*	···	HDE 229 196	···	···	**HD 169 582**
O6.5	**HD 167 633** *HD 91 572* HD 12 993	*HDE 322 417*	HD 190 864 *HD 96 946* *HD 152 723 AaAb* *HD 156 738*	**HD 157 857**	···	···	*HD 163 758*
O7	*HD 93 146 A* HDE 242 926 *HD 91 824* *HD 93 222*	···	Cyg OB2-4 A *HD 93 160*	*HD 94 963* *HD 151 515*	*HD 69 464* HD 193 514	···	···
O7.5	*HD 152 590* HD 35 619	···	*HD 163 800*	HD 34 656 **HD 171 589**	HD 17 603 *HD 156 154*	HD 192 639 **9 Sge**	···
O8	*HD 101 223* *HD 97 848* HD 191 978	*HD 94 024* *HD 135 591*	*HDE 319 702* **λ Ori A**	*63 Oph*	**BD -11 4586**	HD 225 160	*HD 151 804*
O8.5	*HDE 298 429* HD 14 633 **HD 46 149** *HD 57 236* *Trumpler 14-9*	**HD 46 966**	*HD 114 737 AB* HD 218 195 A	*HD 75 211* HD 207 198	*HD 125 241*	···	*HDE 303 492*
O9	10 Lac HD 216 898 *CPD -59 2551*	*HD 93 028* *CPD -41 7733*	*HD 93 249 A* HD 24 431 HD 193 443 AB	*HD 71 304* *τ CMa AaAb*	19 Cep	HD 202 124 *HD 152 249* HD 210 809	α Cam
O9.2	**HD 46 202** HD 12 323	*HD 96 622*	*CPD -35 2105 AB* HD 16 832	···	*HD 76 968*	*HD 154 368* *HD 123 008* HD 218 915	*HD 152 424*
O9.5	AE Aur *μ Col*	HD 192 001 *HD 93 027* *HD 155 889 AB*	*HD 96 264*	**δ Ori AaAb**	···	HD 188 209	···
O9.7	*υ* **Ori**	HD 207 538	HD 189 957 *HD 154 643*	*HD 68 450* *HD 152 405* HD 10 125	**HD 47 432** *HD 154 811* *HD 152 147*	HD 225 146 *μ Nor* *HD 104 565* HD 191 781	HD 195 592 *GS Mus*
Notes	Normal, *italic*, and **bold** typefaces are used for stars with $\delta > +20°$, $\delta < -20°$, and the equatorial intermediate region, respectively.						

Table 1. The OB2500 v2.0 grid of standards.

Spectral classification errors

- Classification errors in the literature:
  - 24.9% of the alleged O stars observed by mid 2013 were not of that type (false positives, Maíz Apellániz et al. 2013).
  - The current number of false positives is closer to 30%.
  - False negatives are much lower (6.4%, Maíz Apellániz et al. 2013).
- SIMBAD has many errors in O-type spectral classifications:
  - Some are actually of photometric, not spectroscopic origin.
  - Other classifications are of unknown origin (no reference provided).
  - Misidentifications (in the source or in SIMBAD) are present.
  - Sometimes the lower quality classification is shown at the top.
- Egregious errors: A-K stars that appear or have appeared in SIMBAD as O stars (Table 2 and Figure 2).

Name	Spectral type		SIMBAD reference	Notes
	SIMBAD	New		
BD -03 2178	O5	K	MacConnell & Bidelman (1976)	Recently fixed in SIMBAD, confusion with BD -03 2179, a sdO
BD +01 3974	O	F	Kelly & Kilkenny (1986)	
BD +32 4642 A	O	F	Not given*	
BD +37 3929	O8f	F	Hiltner & Johnson (1956)	Confusion with BD +37 3927
BD +40 4213	O9.5 I	F	Massey & Thompson (1991)	Not in the original reference, likely transcription error in SIMBAD
BD +45 4132 A	O	F	Not given*	
BD +61 100 AB	O/B2	G	Radoslavova (1989)	
CPD −61 4623	O	K	Not given*	
HDE 226 144	O9 V	A	Mikolajewska & Mikolajewski (1980)	
Tyc 0468-02112-1	O. . .	F	Not given*	

* These classifications were removed from SIMBAD after this poster was presented.

Table 2. Stars classified as O in SIMBAD that are actually of spectral types A to K.

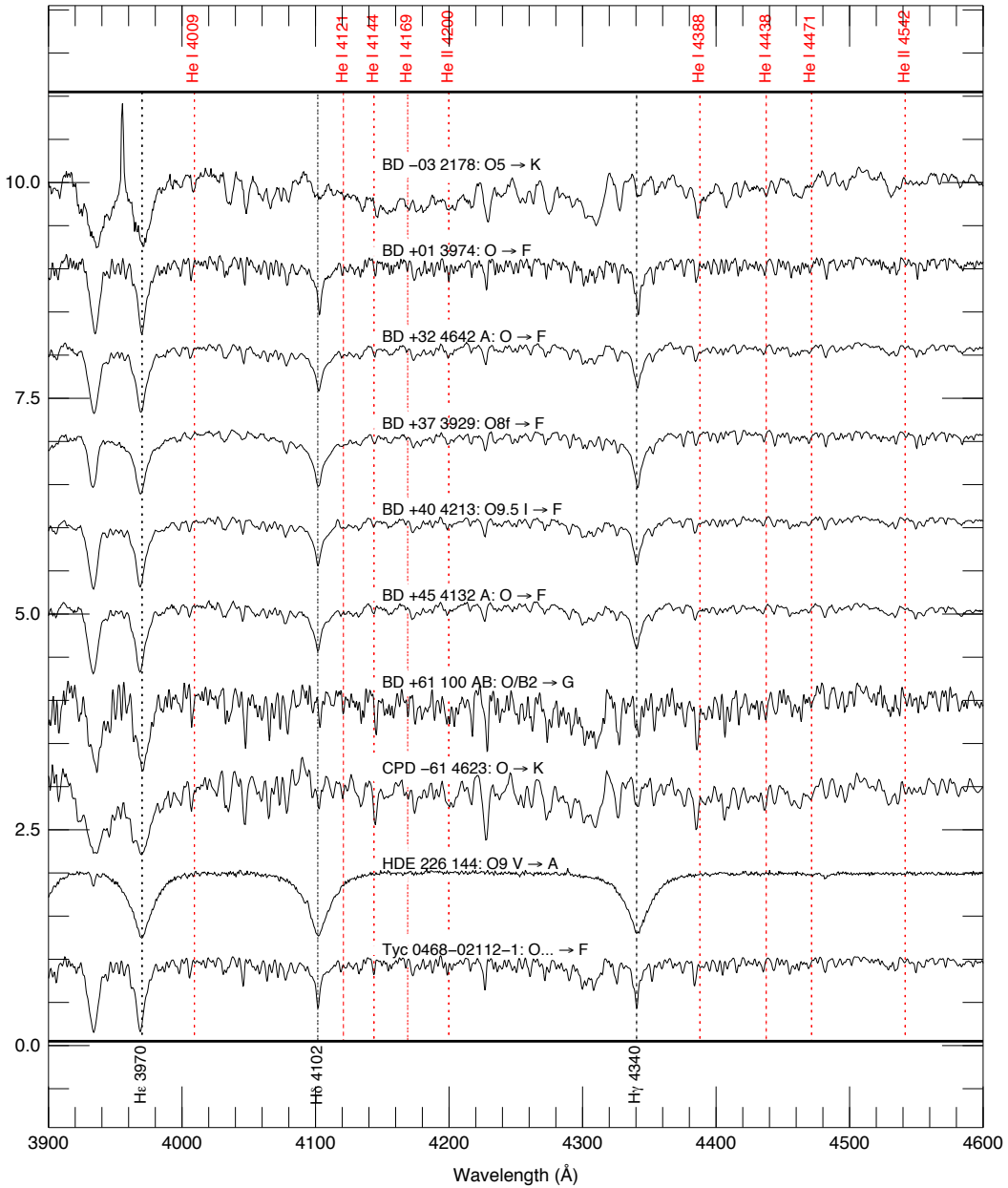

Figure 2. Spectrograms for the stars in Table 2.

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