

Highlights of Spanish Astrophysics VIII, Proceedings of the XI Scientific Meeting of the Spanish Astronomical Society held on September 8 – 12, 2014, in Teruel, Spain. A. J. Cenarro, F. Figueras, C. Hernández-Monteagudo, J. Trujillo, and L. Valdivielso (eds.)

MGB and the new Galactic O-Star Spectroscopic Survey spectral classification standard grid

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Abstract

In this poster we present three developments related to the Galactic O-Star Spectroscopic Survey (GOSSS). First, we are making public the first version of MGB, an IDL code that allows the user to compare observed spectra to a grid of spectroscopic standards to measure spectral types, luminosity classes, rotation indexes, and spectral qualifiers. Second, we present the associated grid of standard stars for the spectral types O2 to O9.7, with several improvements over the original GOSSS grid of Sota et al. (2011). Third, we present a list of egregious classification errors in SIMBAD: stars that are or have been listed there as being of O type but that in reality are late-type stars.

1 What is GOSSS?

GOSSS stands for Galactic O-Star Spectroscopic Survey (Maíz Apellániz et al. 2011). In this project we are observing all Galactic stars that anybody has ever classified as O (if we get time on a large enough telescope) with $R \sim 2500$ spectroscopy in the blue-violet region and a $S/N \sim 300$ (in $\sim 90\%$ of the cases). The telescopes used so far are: 1.5 m OSN, 3.5 m CAHA, WHT, and GTC (north); 2.5 m LCO and Gemini (south). We have 2000+ stars observed so far, with completeness to $B = 8$ ($B = 10$ by 2015) and objects as dim as $B = 16$

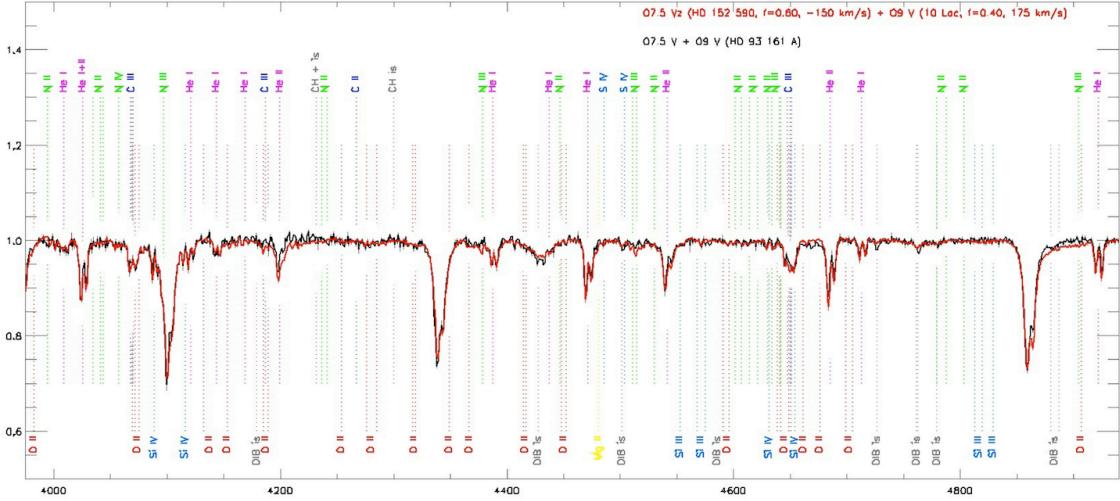


Figure 1: Example of fitting an SB2 system with MGB. Eight parameters can be adjusted: the spectral subtypes, luminosity classes, and velocities of both the primary and secondary, the flux fraction of the secondary, and the rotation index n . Here HD 93 161 A (black) is fitted with a combination (red)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

($B = 19$ planned). In some cases we have multiple epochs for extreme SB2s and variables. GOSSS uses a devoted pipeline and quality control systems.

2 GOSSS goals

The primary goal of GOSSS is spectral classification. More specifically, we aim to:

- Identify and classify all optically accessible Galactic O stars.
- Improve classification criteria and possibly define new special types.
- Identify objects wrongly classified as O.

GOSSS also has five secondary goals:

- Derive physical properties of O stars.
- Study SB2s in collaboration with high-resolution sister surveys (OWN, CAFÉ-BEANS, IACOB, and NoMaDS, see contributions by I. Negueruela and S. Simón-Díaz in these proceedings).
- Study the extinction law and study its relationship with the ISM (see contribution by J. Maíz Apellániz in these proceedings).

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

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

Notes Normal, *italic*, and **bold** typefaces are used for stars with $\delta > +20^\circ$, $\delta < -20^\circ$, and the equatorial intermediate region, respectively.

- Analyze the spatial distribution of massive stars and dust.
- Obtain the massive-star IMF.

3 MGB

MGB is a code that attacks spectral classification (Maíz Apellániz et al. 2012) by doing classical visual (non-automatic) spectral classification by interactively comparing with a standard grid. The MGB user can adjust four parameters:

- Spectral subtype (horizontal classification).
- Luminosity class (vertical classification).
- n index (broadening).

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

Name	Spectral type SIMBAD	Spectral type New	SIMBAD reference	Notes
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.

- Alternative standards at each grid point (e.g. ONC or f variants).

MGB also includes fitting of SB2 systems (Figure 1). The default grid covers the O2-O9.7 spectral subtypes using GOSSS data (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) are planned. MGB v1.0 is available now from <http://jmaiz.iaa.es>.

4 The new GOSSS standard grid

We present the OB2500 v2.0 GOSSS standard grid, which is integrated with MGB. It covers the spectral subtypes from O2 to O9.7 and the luminosity classes from V to Ia (Table 1). The grid has two types of gaps: non-existing types (blank) and standards not yet found (...). It is similar to OB2500 v1.0, the grid in Sota et al. (2011), but with some small changes introduced by Sota et al. (2014) e.g. the addition of O9.2 and new standards. The grid is available from <http://jmaiz.iaa.es> with MGB v1.0. A future extension to A0 (including all B stars) and luminosity class Ia+ is planned.

5 Spectral classification errors

During the course of GOSSS we have discovered a large number of classification errors in the literature. More specifically:

- 24.9% of the alleged O stars observed by mid 2013 were not of that type (false positives, Maíz Apellániz et al. 2013).

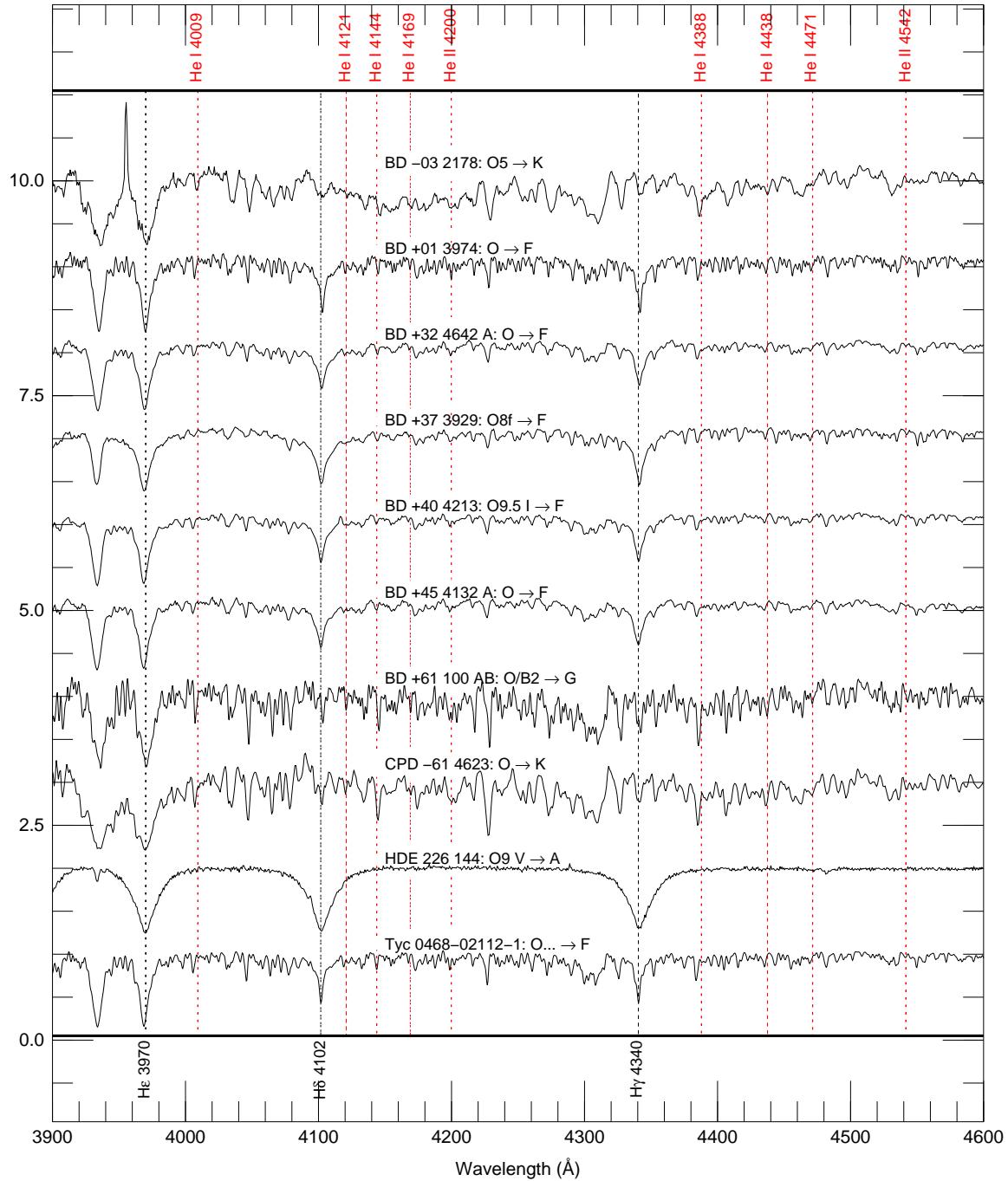


Figure 2: Spectrograms for the stars in Table 2.

- 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, which are related to different issues:

- Some spectral types are actually of photometric, not spectroscopic origin.
- Other classifications are of unknown origin (no reference is provided).
- Misidentifications (in the source or in SIMBAD) are present.
- Sometimes the lower quality classification is shown at the top, leaving the higher quality one “hidden” in the text below.

The most egregious errors we have found are A-K stars that appear or have appeared in SIMBAD as O stars (Table 2 and Figure 2).

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