# The Galactic O-Star Catalog (GOSC) and the Galactic O-Star Spectroscopic Survey (GOSSS): current status

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# What are GOSC and GOSSS?

- GOSC: Galactic O-Star Catalog.
  - On-line catalog for O stars (and relatives): `http://gosc.iaa.es`.
  - v1.0 (Maíz Apellániz et al. 2004) and v2.0 (Sota et al. 2008).
  - v3.2.2 (2016): public (601 objects) and private (7000+ objects) parts.
- GOSSS: Galactic O-Star Spectroscopic Survey (Maíz Apellániz et al. 2011).
  - We observe all optically accessible 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 with S/N $\sim 250$.
  - 2500+ stars observed, complete to $B = 8$, objects as dim as $B = 17$.
  - Limited multiple epochs in some cases for extreme SB2s and variables.
  - Three blocks: GOSSS-I (Sota et al. 2011), GOSSS-II (Sota et al. 2014), and GOSSS-III (Maíz Apellániz et al. 2016).

# GOSC+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).
  - The extinction law and the ISM (poster by J. Maíz Apellániz).
  - The spatial distribution of massive stars and dust.
  - The massive-star IMF.

# What is new in GOSC in the last two years?

- From v3.1.1 to v3.2.2.
- Use of GOSSS DR2.0 from GOSSS-III (Maíz Apellániz et al. 2016) for public spectral types (main catalog and supplements 1-4, Table 1).
- New 1500 objects, including all bright B stars.
- Addition of WISE H II regions in clusters and nebulae field.
- Coordinate revision with new Tycho-2 and 2MASS data.
- Addition of 2MASS catalog numbers and Simbad names.
- Addition of other names (CPD, BD, and ALS).
- Coordination with CDS team at Strasbourg for updates on Simbad spectral types.

| Name | Public? | Description |
|---|---|---|
| Main | Yes | Galactic O stars |
| S01 | Yes | Galactic WR and WR+O systems |
| S02 | Yes | Other Galactic early-type stars |
| S03 | Yes | Galactic late-type stars |
| S04 | Yes | Extragalactic massive stars |
| S05 | No | Galactic O stars |
| S06 | No | Galactic WR and WR+O systems |
| S07 | No | Other Galactic early-type stars |
| S08 | No | Galactic late-type stars |
| S09 | No | Extragalactic massive stars |
| S10 | No | Galactic early-type candidates not observed with GOSSS |
| S11 | No | Galactic late-type candidates not observed with GOSSS |
| S12 | No | Extragalactic candidates not observed with GOSSS |
| S13 | No | Close companions unresolved in GOSSS |

**Table 1.** Main catalog and supplements in GOSC.

# What is new in GOSSS in the last two years?

- GOSSS-III (Maíz Apellániz et al. 2016): see below.
- $\sim$1000 objects observed in the last two years alone.
- New telescopes added: GTC, Liverpool, SOAR, and Gemini South.
- OSIRIS@GTC (10.4 m):
  - Northern dim stars ($14 < B < 17$).
  - Filler program, several hundred objects already observed (Figure 1).
- FRODOspec@Liverpool (2.0 m):
  - Northern bright stars ($11 < B$).
  - Robotic telescope with miniIFU (Figure 2).
  - Specific pipeline designed (all other setups are with long slits).
- New versions of MGB and the OB2500 standard grid: see below.

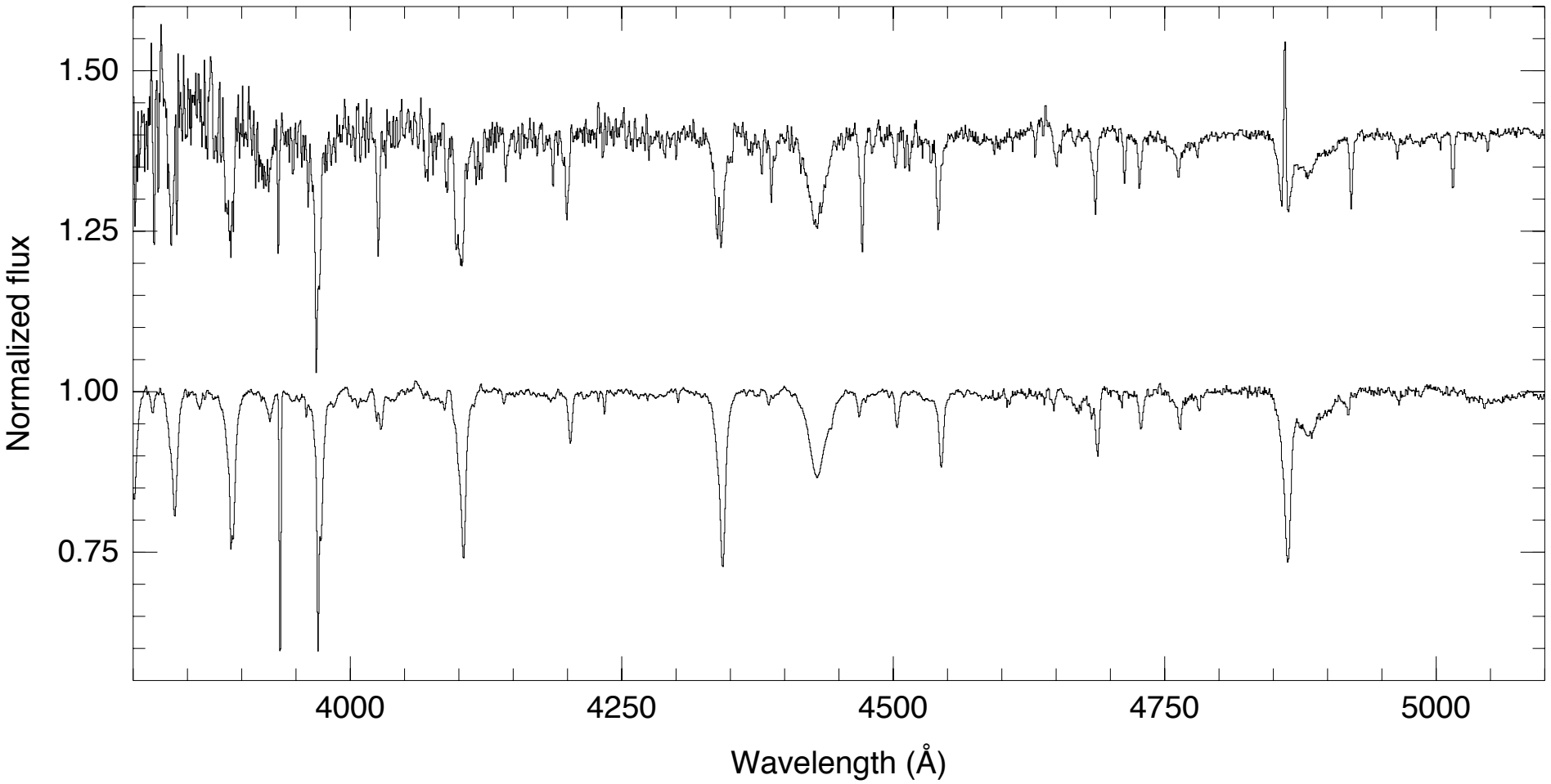


**Figure 1.** Two examples of GOSSS GTC spectra. [top] A newly discovered O7.5 III((f))p star, whose spectrum likely reveals a strong magnetic field, a rarity among O stars. [bottom] A new O3 V((f*)) + O9.5 V: spectroscopic binary system. The primary is the earliest known O dwarf in the northern hemisphere.

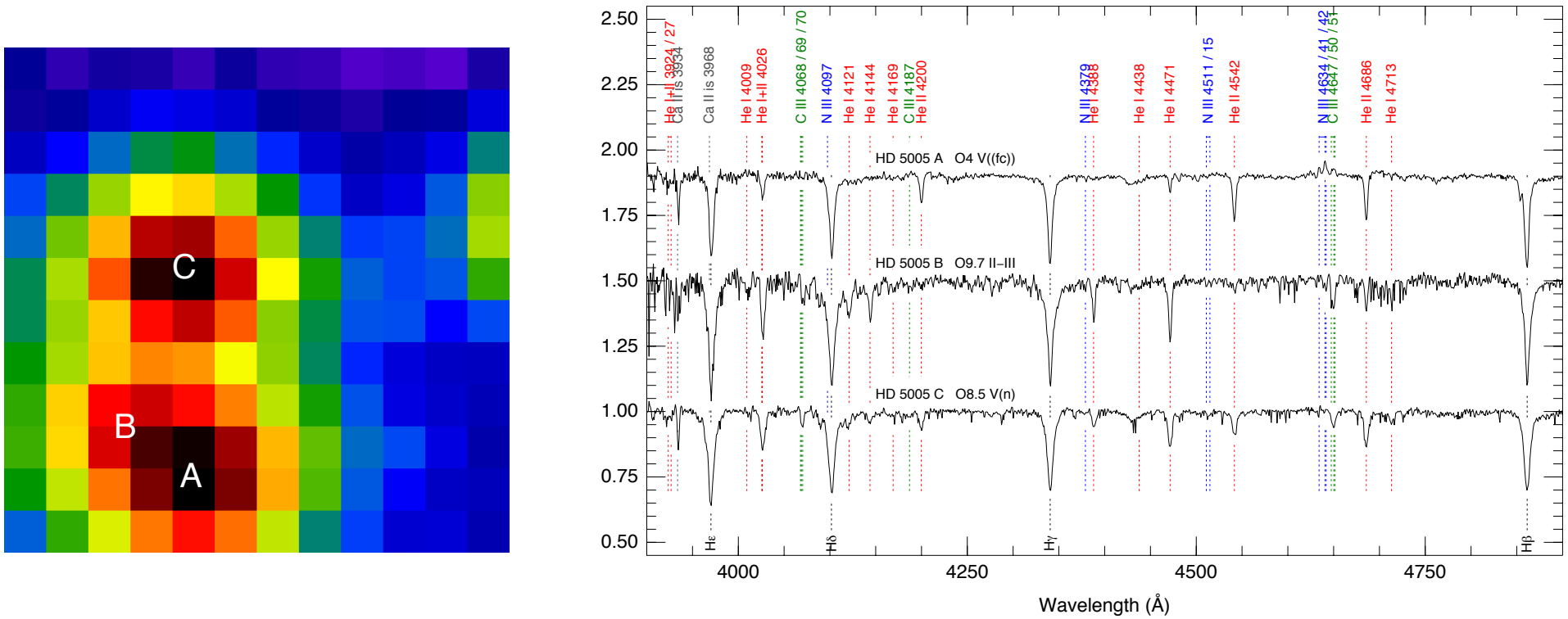


**Figure 2.** [left] Wavelength-collapsed FRODOspec@Liverpool image of the multiple system HD 5005 A+B+C (a D component is located just outside the field to the right). The letters indicate the positions of the three stars. The field size is $9\farcs84 \times 9\farcs84$ and corresponds to a grid of $12 \times 12$ fibers. [right] Pipeline-extracted spectra of the three stars. The pipeline fits a triple Moffat profile at each wavelength point and iterates after fitting a polynomial in wavelength to the PSF parameters.

# GOSSS-III

- Third block of the GOSSS project (Maíz Apellániz et al. 2016).
- Includes GOSSS DR2.0.
- 142 additional stellar systems with O stars, for a total of 590 in GOSSS DR2.0.
- 20 new O stars.
- 11 new SB2 systems: 6 of O+O type and 5 of O+B type.
- Revisions of previous GOSSS spectral types, including adaptations to the OV/OVz scheme of Arias et al. (2016).
- Presentation of egregious errors in the literature: late-type stars classified as O type.
- Introduction of luminosity class IV for spectral types O4-O5.5.

# 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 3).
- Default grid: OB2500 v3.0, O2-O9.7 from GOSSS (see below).
- Other grids (O-type or other) from different on-going high-resolution surveys (e.g. IACOB, OWN, IACOBsweG) or from atmosphere models.
- MGB v2.0 available now from `http://jmaiz.iaa.es`.

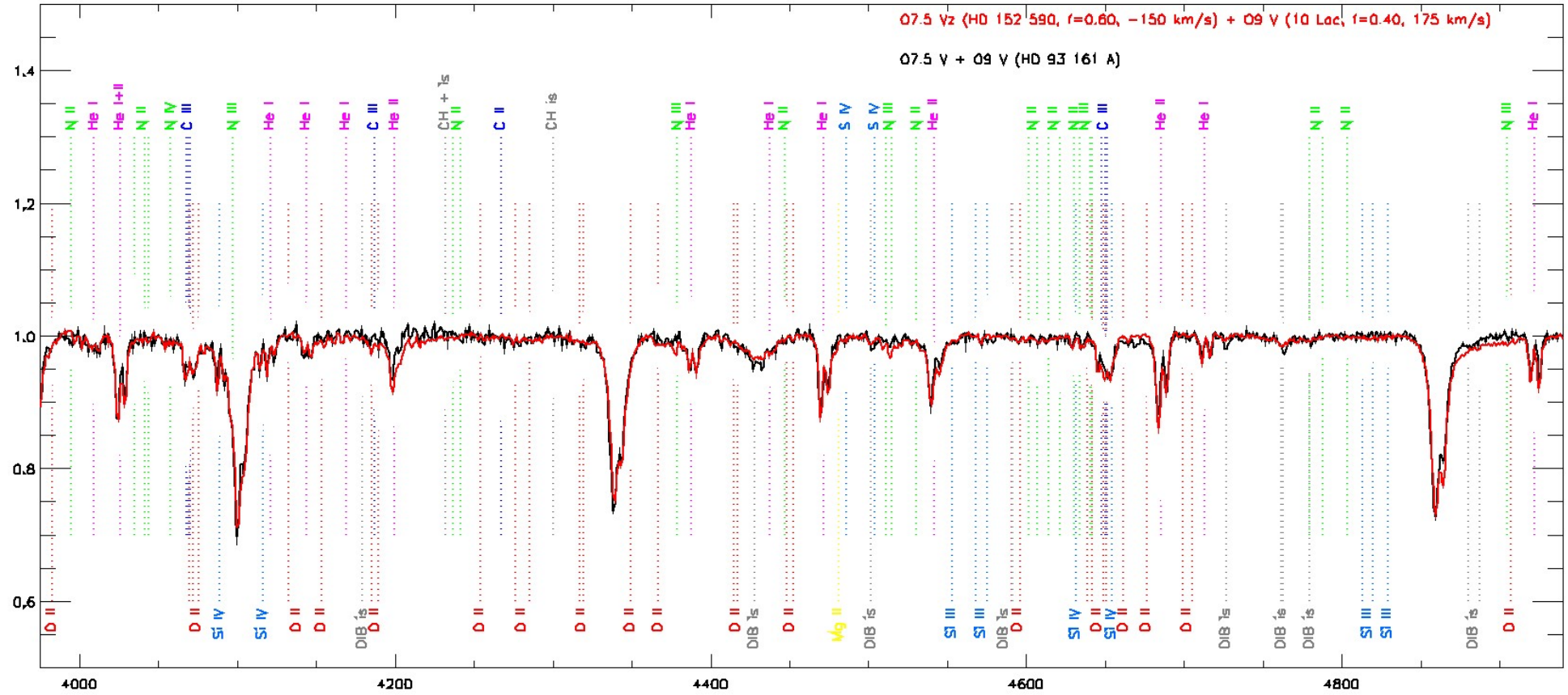


**Figure 3.** Example of fitting an SB2 system with MGB. Eight parameters can be adjusted: the spectral subtypes, luminosity classes, and velocities of both the primary and secondary, the flux fraction of the secondary, and the rotation index n. Here HD 93 161 A (black) is fitted with a combination (red) of 60% of HD 152 590 and 40% of 10 Lac separated by 325 km/s.

# The GOSSS standard grid

- OB2500 v3.0 grid: integrated with MGB.
- It covers spectral subtypes from O2 to O9.7 and luminosity classes from Vz to Ia (Table 2).
- Two types of gaps: non-existing types (blank) and standards not yet found (. . . ).
- Similar to OB2500 v2.0, the grid in Maíz Apellániz (2015), but with small changes introduced by Maíz Apellániz et al. (2016): addition of the Vz luminosity class, definition of luminosity class IV for O4-O5.5, and introduction of new standards.
- Available from `http://jmaiz.iaa.es` with MGB v2.0.
- Future extension to A0 (including all B stars) and luminosity class Ia+.

# The GOSSS future

- Extension from 590 O stars to ∼1500 in the next decade.
- Publication of other 3000 spectra and spectral types (mostly B stars) in the same period.
- We expect to discover several tens of new SB2 systems.
- Combination with Gaia and other surveys: the 6-D distribution of O stars in the solar neighborhood.
- Use of photometric surveys (e.g. GALANTE) to expand the sample.
- Complete sample expected for the two outer Galactic quadrants (low extinction) at the end of survey. The two inner quadrants require (a) multifiber surveys such as WEAVE and (b) IR surveys.
- The spatial distribution of dust as a function of grain size.
- Standard grids for the whole OB spectral range.

# References


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| | Vz | 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* | | | *NGC 3603 HST-48* | |
| O4 | *HD 96 715* | **HD 46 223** | **HD 168 076 AB**<br>*HD 93 250 AB* | ··· | | | HD 15 570<br>HD 16 691<br>HD 190 429 A | |
| O4.5 | ··· | HD 15 629<br>*HDE 303 308 AB* | HD 193 682 | ··· | | | HD 14 947<br>Cyg OB2-9 | |
| O5 | **HD 46 150** | *HDE 319 699* | **HD 168 112 AB** | *HD 93 843* | | | *CPD -47 2963 AB* | |
| O5.5 | ··· | *HD 93 204* | ··· | ··· | | | Cyg OB2-11<br>*ALS 18 747* | |
| O6 | HD 42 088<br>*HDE 303 311* | **ALS 4880**<br>*CPD -59 2600* | *HD 101 190 AaAb* | HDE 338 931 | HDE 229 196 | ··· | ··· | **HD 169 582** |
| O6.5 | *HD 91 572* | **HD 167 633**<br>HD 12 993 | *HDE 322 417* | HD 190 864<br>*HD 96 946*<br>*HD 152 723 AaAb*<br>*HD 156 738 AB* | **HD 157 857** | ··· | ··· | *HD 163 758* |
| O7 | *HD 97 966*<br>*CPD -58 2620*<br>HDE 242 926<br>*HD 91 824* | *HD 93 146 A*<br>*HD 93 222 AB* | ALS 12 320 | Cyg OB2-4 A<br>*HD 93 160 AB* | *HD 94 963*<br>*HD 151 515* | *HD 69 464*<br>HD 193 514 | ··· | ··· |
| O7.5 | *HD 152 590* | HD 35 619 | *HD 97 319* | *HD 163 800* | HD 34 656<br>**HD 171 589** | HD 17 603<br>*HD 156 154* | HD 192 639<br>**9 Sge** | ··· |
| O8 | *HDE 305 539*<br>*HDE 305 438* | *HD 101 223*<br>*HD 97 848*<br>HD 191 978 | *HD 94 024*<br>*HD 135 591* | *HDE 319 702*<br>$\lambda$ **Ori A** | *63 Oph* | **BD -11 4586** | HD 225 160 | *HD 151 804* |
| O8.5 | | *HDE 298 429*<br>HD 14 633 AaAb<br>**HD 46 149**<br>*HD 57 236*<br>*Trumpler 14-9* | **HD 46 966 AaAb** | *HD 114 737 AB*<br>HD 218 195 A | *HD 75 211*<br>HD 207 198 | *HD 125 241* | ··· | *HDE 303 492* |
| O9 | | 10 Lac<br>HD 216 898<br>*CPD -59 2551* | *HD 93 028*<br>*CPD -41 7733* | *HD 93 249 A*<br>HD 24 431 | *HD 71 304*<br>$\tau$ *CMa AaAb* | 19 Cep | HD 202 124<br>*HD 152 249*<br>HD 210 809 | $\alpha$ Cam |
| O9.2 | | **HD 46 202**<br>HD 12 323 | *HD 96 622* | *CPD -35 2105 AaAbB*<br>HD 16 832 | ALS 11 761 | *HD 76 968* | *HD 154 368*<br>*HD 123 008*<br>HD 218 915 | *HD 152 424* |
| O9.5 | | AE Aur<br>$\mu$ *Col* | HD 192 001<br>*HD 93 027*<br>*HD 155 889 AB* | *HD 96 264* | $\delta$ **Ori AaAb** | ··· | HD 188 209 | ··· |
| O9.7 | | $\upsilon$ **Ori** | HD 207 538 | HD 189 957<br>*HD 154 643* | *HD 68 450*<br>*HD 152 405*<br>HD 10 125 | **HD 47 432**<br>*HD 154 811*<br>*HD 152 147* | HD 225 146<br>$\mu$ *Nor*<br>*HD 104 565*<br>HD 191 781 | HD 195 592<br>*GS Mus* |

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

**Table 2.** The OB2500 v3.0 grid of standards.