Gaia-ESO Survey Working Group 14

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Outliers classification
Version 2
WG 14

1 Motivation

With the rise of large spectroscopic surveys, several methods of outliers detection (e.g., Tomasella et al. 2010) have been developed. *Unexpected* outliers detection can proceed, for example, through principal component analysis or morphological classification (e.g., Matijevič et al. 2012), and need to be carefully calibrated with template spectra of *known* outliers. *Expected* outliers, in turn, can be efficiently detected and classified with well-tuned spectral indices.

It has to be kept in mind that the outliers that will be detected within the GES will be used by people with very different expertise, and for very different purposes. Therefore, when trying to define a classification scheme for outliers, we should not (only) consider our specific needs, but imagine what information would be at the same time useful, exact and exhaustive, for GES-consortium users, but also (especially) for people external to the GES consortium, not necessarily aware of internal issues that have been extensively discussed within the GES consortium.

It is primarily the task of WG14 to flag outliers. However, it appeared that many WG are flagging various types of outliers but with their own naming convention. It seems desirable to use from the beginning of the data release procedure a common dictionary, as described in the present document.

2 GES data

UVES and GIRAFFE spectra are available in different settings, as described on the GES wiki DR pages (http://great.ast.cam.ac.uk/GESwiki/GeSDR1). In brief, UVES setting 580 (4768-5801Å and 5822-6830Å) is mainly used, while many different settings (HR10 5334-5611Å, HR15 6444-6816Å, HR21 8475-8982Å, + HR 3, 5, 6, 14, ...) are used for GIRAFFE. Photometric information is available in the multi-extension FITS files (in rough numbers, for DR1: JHK 2MASS (90%), LHK VHS (33%), SDSS ugriz (20%), APASS bvgri (15%), UKIDSS JHK (11%)).

3 Stellar classification

In a general framework, several types of classification can be considered, in particular:

- **Phenomenological classification**: Phenomenological classification is purely based on observational facts. It is, of course, strongly connected to Morgan-Keenan (MK) spectral classification, but may accept additional pieces of information (e.g. rotation, photometry) and omit others. Phenomenological classification is not directly related to the evolutionary status of objects.

- **Spectral classification**: We shall consider here the - by far - most widely used, MK classification scheme, relying on an inductive (bottom-up) logic, constructing a system (made of *classes*) from specific examples (*specimens*), allowing for interpolation between specimens. As reviewed in Gray & Corbally (2009), MK classification is only based on spectroscopic information, and ignores external information such as photometry or theory.

- **Evolutionary classification**: Assigning an evolutionary stage to a series of spectroscopic or photometric indicators implies an interpretation, based on theories and models, and inevitably subject to changes. The MK classification scheme durability lies precisely on the fact that it is theory-, interpretation- and calibration-independent.

4 Proposed GES outliers classification

Given the data available for GES objects, it appears that, at least in specific cases, spectral and photometric information can be combined to strengthen the diagnostic. Since outliers (i.e., unusual stars) are concerned, a precise MK classification might be difficult to assign to all objects. Moreover, because of the restricted spectral ranges and medium resolution of GIRAFFE settings, MK classification is anticipated to be extremely difficult for GIRAFFE spectra.

Therefore, a compromise for outliers classification would be:

- to use both a phenomenological classification and, when/if possible, a MK-like classification.

- to combine information from different sources when available (spectroscopic, photometric, literature).

The following scheme is proposed:

Stars are assigned a peculiarity flag, built from the juxtaposition of a peculiarity index XXXX (between 0000 and 9999) and 1 or 2 confidence flag letter (Z):

- A=probable

- B=possible

- C=tentative

- D=preliminary (WG14 use only)

XXXXZ = PeculiarityFlag = PeculiarityInteger | ConfidenceFlagLetter

Several PeculiarityFlags can be attached to a single object.

For example: 2356B, 4050B, 1011A, 1013A

would flag a possible symbiotic star, possible baryum star, and with clear H_α emission.

Flag D would be used by WG14 only, to trace taggingss coming from other WG, before homegenisation.

A tentative list of peculiarity integers is displayed in Appendix 1, taking into account received feedback (by May 2013).

5 Tentative outliers tagging timescale

WG14 develops its own tools to tag outliers. However, it seems desirable to interact during a DR processing with other WG, for example as described in the following timetable:

iDR number
Reprocessed spectra, RV, photometry until:
... released to WG on:
First pass: **Outliers homogenisation 1 (rotation, binarity, ...)**
Astrophysical parameters:
Abundance determinations: **Outliers homogenisation 2**
Homogenisation: **Final outliers homogenisation**
Parameters released by Edinburgh to Survey Co-Is

References

Gray, R. O. & Corbally, J., C. 2009, Stellar Spectral Classification

Matijevič, G., Zwitter, T., Bienaymé, O., et al. 2012, ApJS, 200, 14

Tomasella, L., Munari, U., & Zwitter, T. 2010, AJ, 140, 1758

Appendix 1: Outliers dictionnary

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Confidence flag:
A=probable
B=possible
C=tentative
(D=preliminary, WG-14 only)

0000 no tested anomaly detected

PECULI flag : PHENOMENOLOGICAL CLASSIFICATION: 1000-2999

1000 Emission-line stars
  1ZZI emission line of element with atomic number Z=ZZ (0-99) and
       ionization level I (spectroscopic notation, 1-9, 1=neutral).
       (from 1011 to 1999). Ex: 1021: He I emission
  1010 Suspiscion that (Halpha) emission lines are extrinsic rather than intrinsic
       (e.g. from HII region in the line of sight)
  1013 In particular: Balmer Halpha
  1014 In particular: Balmer Hbeta
  1015 In particular: Paschen
2000 Binaries
  2005:      Stars with large radial velocity variations, indicating either large
             jitter or binary motion
  2010: SB1: Stars with radial velocity variations larger than expected jitter
             for its type, indicating probable binary motion
  2020 SBn,n>=2
  2030 SBn,n>=3
  2040 SBn,n>=4
2100 Abnormal rotators
2300 Abnormally strong absorption lines
  23ZZ enhanced line of element with atomic number Z=ZZ (0-99)
       (from 2301 to 2399). Ex: 2303: abnormally strong Li line
2400 Abnormally strong molecular bands
  2412 enhanced MgH
  2414 enhanced SiH
  2420 enhanced CaH
  2422 enhanced TiO
  2423 enhanced VO
  2426 enhanced FeH
  2440 enhanced ZrO
  2457 enhanced LaO
  2462 enhanced 12CH
  2463 enhanced 13CH
  2472 enhanced 12C12C
  2473 enhanced 13C13C
  2482 enhanced 12CN
  2483 enhanced 13CN
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REMARK flag: SPECTRAL CLASSIFICATION: 3000-8999
3000 C/O < 1 stars
  3010  M
  3020  dwarf M
  3030  Ba
  3040  dwarf Ba
  3050  S
3100 C/O >=1 stars
  3110  N
  3120  J
  3130  R
  3140  SC
  3150  CH
  3160  C-hydrogen -deficient
  3170  strong-N
  3180  weak-G
  3190  Carbon-enriched-metal-poor (CEMP) CEMP-no
  3200  CEMP-r
  3210  CEMP-s
  3220  dwarf C
3300 Non C-enriched, metal-poor stars (general)
  3300  r-I
  3310  r-II
  3320  UMP stars (i.e., [Fe/H] < -4.0)
4000 Others
  4010 Am
  4011 Fm
  4020 Ap
  4030 SrCrEu
  4040 lambda Boo
  4050 Symbiotics
  4060 Novae (classical, dwarf, ...)
  4070 Cataclysmic variables
  4080 Flare stars
  4090 BY Dra
  4100 RS CVn
  4110 FK com
  4120 R CrB
  4130 T Tauri
  4140 weak T Tauri
  4150 HAeBe
  4160 FU Ori
  4170 Cepheids
  4200 Post AGB, pre-PN
  4210 RV Tauri
  4300 White dwarfs

TECH flag:
9000 ANALYSIS PROBLEMS OR UNKNOWN SPECTRA
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9010 Too low SNR to allow classification
9020 Radial velocity determination problem or discrepant radial velocities
9030 Data reduction issues
9040 Incompatibility between spectroscopy and photometry
9100 Unknown spectrum
