SF2A 2014
J. Ballet, F. Bournaud, F. Martins, R. Monier and C. Reylé (eds)

ADDITIONAL AUXILIARY DATA FOR THE GAIA-RVS

F. Crifo[1], L. Chemin[2], G. Jasniewicz[3], D. Katz[1], O. Marchal[1], P. Sartoretti[1], C. Soubiran[2], F. Thévenin[4] and T. Zwitter[5]

Abstract. The Gaia-RVS will measure some 10^8 stellar radial velocities using the correlation method with well-adapted template spectra for each individual case. Ground-based RV standards will be used to fix the zero-point.

Gaia instruments are "self-calibrating" and no calibration device is available on board. But for the beginning of the mission, until the needed calibration parameters become available, the calibrations have to come from external sources, i.e. existing ground-based observations of already very well-known objects. Therefore beside the basic list of 1400 very stable and well-measured primary standards, several secondary RV lists have been built recently. The basic list itself will be extended with around 500 new "primary standard".

The libraries of existing spectra have been carefully investigated: a lot of high-quality material is available for the start of the reductions and for the validation of the pipeline results.

In addition, as the data expected from the photometric instrument are not available at the beginning, very large lists with atmospheric parameters (T_{eff}, $\log g$, metallicity) have been produced from the literature.

Grids of 3D atmospheric models have been calculated, in order to select the best template for the correlation; they will be used in the future and will automatically take into account the stellar convective shift across the HR diagram.

Keywords: Stars: fundamental parameters; Techniques: radial velocities; Surveys: Gaia.

1 Need for additional ground-based data

Gaia was successfully launched December 19th, 2013. After arrival at the L2 point in January 2014, the commissioning period was somewhat extended due to some initial unexpected difficulties. The routine scanning of the sky started on July 25. Spectra are now regularly produced and reduced on the ground. However the reduction process is supposed to use data concerning the targets, that should be derived from the BP/RP observations. Such data is of course not yet available. Therefore several lists of preliminary data have been built:

- the Initial Gaia Source List (IGSL), built by R. Smart (see Smart 2013);

- the list of radial velocity standards (Soubiran et al. 2013; Crifo et al. 2010) for which in addition atmospheric parameters (T_{eff}, $\log g$, $[Fe/H]$) have been searched in the literature.

However, for this beginning period, it is also desirable to have MORE standards available, on the order of 1 per hour: this is a total of about 2000 stars if they are regularly distributed over the whole sky. Despite our efforts, it is not the case with the present list of 1400 standards, with which the largest interval between two consecutive transits may be as large as 8 hours, while the rotation period of Gaia is 6 hours. Therefore it was decided to build additional lists of standards, with of course less accuracy and reliability than the main list, as new observations cannot be conducted on time. A total of 10000 stars are expected.

Also, lists of atmospheric parameters have been compiled for large sets: Hipparcos stars, Tycho stars, part of 2MASS stars. The ESA/Gaia Technical Note (TN) by Katz et al. (2012) describes the list of additional ground-based data needed. The TN by Marchal et al. (2014) describes the practical realization of these lists and their inclusion in the reduction pipeline.

---

[1] GEPI (UMR 811 du CNRS; Université Paris 7, FRANCE), Observatoire de Paris, 92190 MEUDON, FRANCE
[2] LAB, UMR 5804, Université de Bordeaux, CNRS, 2 rue de l'Observatoire, F-33270 FLOIRAC, FRANCE
[3] GRAAL, UMR 524, CNRS, Université Montpellier 2, FRANCE
[4] OCA/Cassiopée, UMR CNRS 6062, Observatory of the Côte d'Azur, Le Mont Gros, BP 4229, 06304 Nice Cedex 4, FRANCE
[5] University of Ljubljana, SLOVENIA

2 Secondary RV standards

A total of about 10000 stars should be provided. Radial velocities for secondary standards have to come from existing catalogue compilations, with the following conditions: FGK types, V≤ 11; not known as double or variable, stable in RV, and with a "clean environment" to avoid overlap of neighbouring spectra.

The sources we used are:

1. Good Hipparcos (HIP) stars already examined during the search of primary list (the so-called "masterlist" with no disturbing neighbours, described in Crifo et al. 2010) but with RVs from literature. The XHIP Catalogue (Anderson & Francis 2012), which compiles a very large set of data of all types for the HIP stars, was adopted as RV source. 7730 stars are found, with an RV accuracy better than 1 km/s. This list is described in the TN by Crifo et al. (2014).

2. A subset of 3800 stars selected in the RAVE survey, with: at least 2 observations; error $\leq$ 1 km/s; 4500 K $\leq T_{eff} \leq$ 7000 K; V $\leq$11; and provided in the TN by Zwitter et al. (2014).

3. 2259 stars selected in the archives of the ELODIE and SOPHIE spectrographs at OHP, 25% of which have enough observations to prove their long-term stability and become additional primary standards (see the TN by Soubiran et al. 2014a). A selection is still going on within the ESO archive and the libraries of spectra from ESPADONS and NARVAL, the HR spectrographs at CFHT and TBL (Pic du Midi). This spectral library is detailed in the TN by Chemin & Soubiran (2014).

4. Other data available for RV validation, particularly for faint stars.

Figure 1 (left) shows the present map of standards: black = primaries ; red = HIP/XHIP secondaries (list 1); green = RAVE selection (list 2) . With the secondary standards the stellar density is enhanced with respect to the primary ones only; however we notice that the area along the Galactic Plane is still underpopulated, particularly in the South.

Figure 1 (right) shows the first comparison of a RVS spectrum; and the same star as in the NARVAL spectra library: it is possible here to see the quality of the RVS spectra.

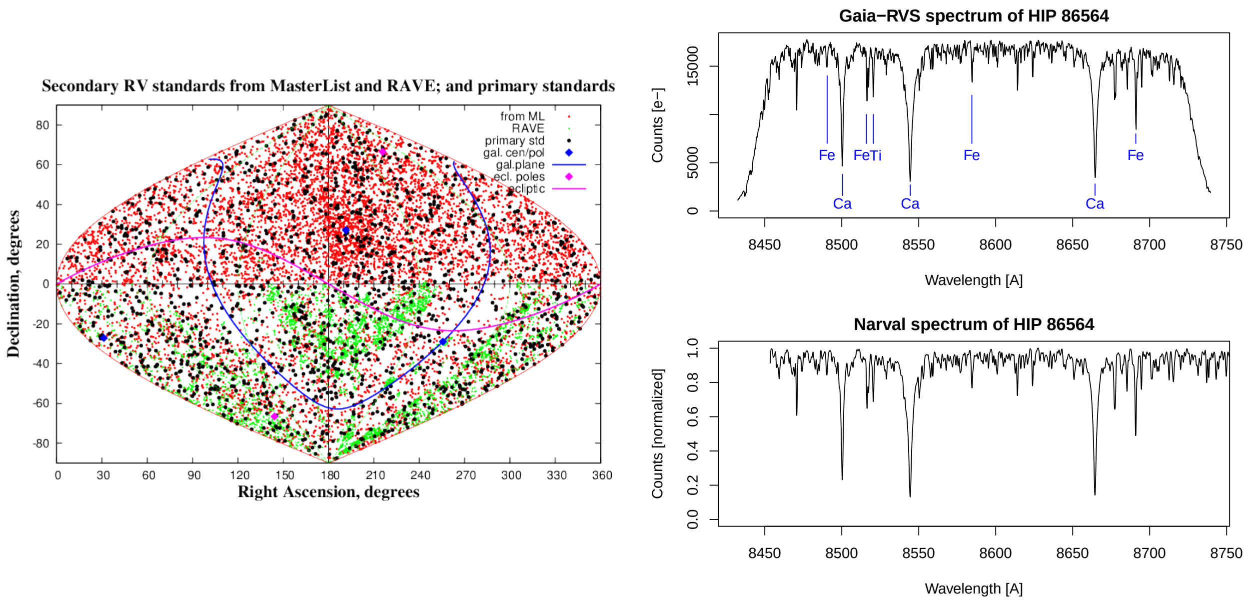

Fig. 1. Left: Map of standards. **Right:** RVS spectrum of HIP 86564 compared with a ground-based spectrum obtained with NARVAL. The NARVAL spectrum has been convolved with the RVS nominal resolution.

3 Atmospheric Parameters (AP)

In the reduction procedure, the RV is calculated by several methods. All of them use the correlation with a synthetic template spectrum adapted to the star. Synthetic spectra are currently computed with 1D or 2D atmospheric models. In a near future they will be computed from 3D models (T_{eff} , $\log g$, $[Fe/H]$), see sect. 4. For each star, approximate values of the three parameters must be known in advance and tabulated in auxiliary lists.

Large-scale analyses have been performed and libraries of APs have been made, from existing lists and catalogues. In particular the TN by Soubiran et al. (2014b) includes parameters from Casagrande et al. (2011) and Ammons et al. (2010), and the TN by Zwitter et al. (2013) derives effective temperatures from 2MASS photometry. The most important parameter is T_{eff} , which remains poorly known for spectral types earlier than F8 and for stars fainter than V=13. Comparisons have been made between various sources to check the validity of the parameters. For instance, Figure 2 shows the comparison between temperatures in the TN of Soubiran et al. (2014b) and Zwitter et al. (2013) with temperatures from Casagrande et al. (2011) for cool stars.

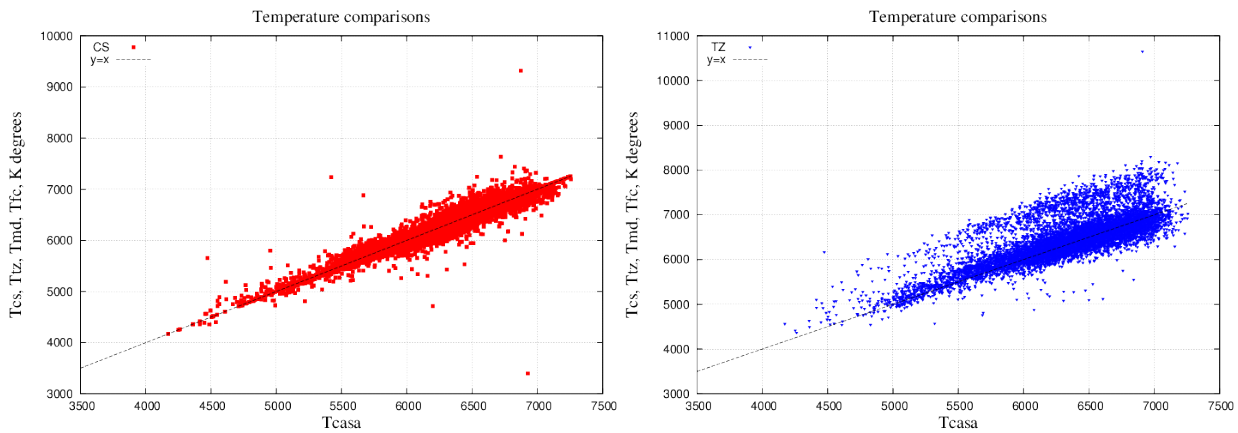

Fig. 2. T_{eff} **comparisons. Left:** Soubiran et al. (2014b) vs Casagrande et al. (2011). **Right:** Zwitter et al. (2013) vs Casagrande et al. (2011).

4 Grids of synthetic spectra

Calculating a 3D synthetic spectrum adapted to each RVS source cannot be envisaged, for reasons of disk space and computational time. Therefore high-resolution synthetic spectra will be calculated only for a limited number of points on a 3D-grid in (T_{eff} , $\log g$, $[Fe/H]$) space. For a given star of known AP, the spectrum is interpolated between the closest points of the grid.

Figure 3 (left) shows the grid with the calculated points, for cool stars. The point not exactly aligned in the grid marks the location of the Sun. Figure 3 (right) shows the difference between spectra computed with different parameters.

5 Conclusion

All kinds of auxiliary data for stars, and in particular ground-based RVs and synthetic spectra are of central importance for the calibration and the zero-point determination of the RVS. They are currently playing a crucial role at the beginning of the mission. At this time (launch + 6 months), there is a large effort within DU640 to gather these required auxiliary data.

Many thanks go to all the CU6 staff not listed in the authors; and to the Centre de Données de Strasbourg, where an incredible amount of recent and old data can be retrieved quite easily.

Short remark: In the bibliographic list here below, the papers referenced as "Gaia Data processing...", that describe the most accurately the developments made within the Gaia DPAC Consortium, are NOT accessible to non-members of the Consortium. Sorry for that.

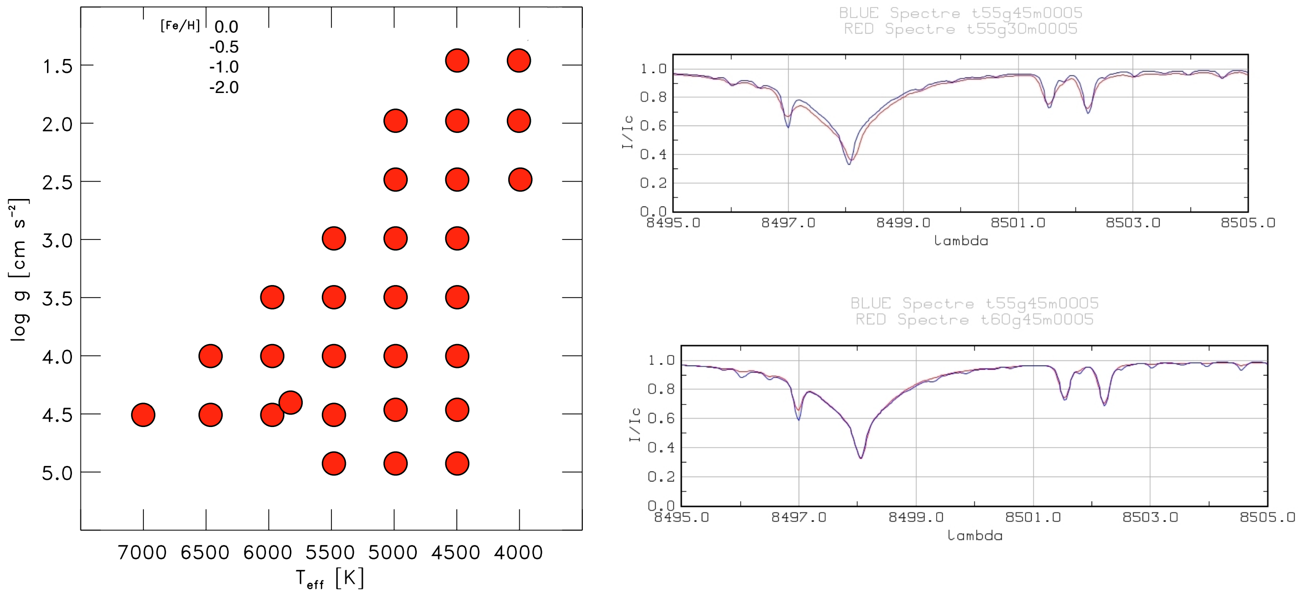

Fig. 3. Left: Grid of calculated synthetic spectra, with the nodes. **Right:** Calculated synthetic spectra, effects of gravity (upper panel) and T_{eff} (lower panel). From Chiavassa et al. 2014 (private communication).

References

Ammons, S. M., Robinson, S. E., Strader, J., et al. 2010, VizieR Online Data Catalog, 5136, 0

Anderson, E. & Francis, C. 2012, Astronomy Letters, 38, 331

Casagrande, L., Schönrich, R., Asplund, M., et al. 2011, A&A, 530, A138

Chemin, L. & Soubiran, C. 2014, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-CU6-TN-LAB-LCH-002-1

Crifo, F., Jasniewicz, G., Soubiran, C., et al. 2010, A&A, 524, A10

Crifo, F., Sartoretti, P., & Katz, D. 2014, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-OPM-FCO-002-1

Katz, D., Soubiran, C., Chemin, L., et al. 2012, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-OPM-DK-015-01

Marchal, O., Sartoretti, P., Crifo, F., & Katz, D. 2014, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-OPM-OML-002-1

Smart, R. 2013, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C3-TN-OATO-RLS-004-02

Soubiran, C., Chemin, L., & Lecampion, J.-F. 2014a, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-LAB-CS-013-1

Soubiran, C., Jasniewicz, G., Chemin, L., et al. 2013, A&A, 552, A64

Soubiran, C., Lecampion, J.-F., & Chemin, L. 2014b, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-LAB-CS-011-2

Zwitter, T., Kos, J., & Zerjal, M. 2013, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-LU-TZ-1-2

Zwitter, T., Kos, J., & Zerjal, M. 2014, Gaia Data Processing & Analysis Consortium Internal Publications, GAIA-C6-TN-LU-TZ-2-D