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TOWARDS A NEW SET OF RADIAL VELOCITY STANDARDS FOR GAIA

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Abstract. The ESA GAIA mission (launch expected end 2011) will measure positions, proper motions, parallaxes and very low resolution spectra for about 10^9 objects, and produce radial velocities and spectra for about 10^8 objects using the Radial Velocity Spectrometer (RVS). Although Gaia is usually labelled as a self-calibrating instrument, some external calibrations are mandatory, especially for radial velocities and photometry. A coordinated plan of ground-based observations is being organised in support of Gaia to obtain the necessary auxiliary data. In particular, the calibration of the wavelength scale and zero-point of the radial velocities will rely on asteroids and on a set of about one thousand reference stars. Such stars must be selected from larger existing lists with drastic criteria and qualified as radial velocity standards from ground based observations. This poster describes the selection of stars, the observing programme on various telescopes and the first results obtained with the ELODIE and SOPHIE spectrographs.

1 The Gaia Radial Velocity Spectrometer (RVS)

The RVS is the spectroscopic instrument onboard Gaia, designed mainly for measuring radial velocities of the bright part of the Gaia targets. It is a slit-less spectrograph, with no calibration device onboard. The spectral interval (847-874nm), containing the IR CaII triplet visible in almost all types of stars, is recorded with a spectral resolution of 11500. For a G2V star the expected accuracy is about 1km/s for $V \leq 13$, and 15 km/s at $V \sim 16.5$. 100 to 150 million stars will be observed. This very large amount of new spectroscopic data will allow considerable advance in the dynamical and chemical study of the Galaxy and stellar physics, and the derivation of stellar astrophysical parameters; it will enable the detection and characterization of multiple systems and pulsating stars, and correction of the perspective effect for the very accurate parallaxes of nearby stars.

Gaia should be launched end 2011 for a 5-years mission at the L2 Lagrange point. Due to the scanning law, each object will be observed by the RVS about 40 times on average. The scientific payload is now in phase C at ESA; the prime contractor is EADS-Astrium. The preparation of data processing is taken in charge by the DPAC Consortium, a pan-European consortium chaired by F. Mignard. More details on the instruments and program may be found at: http://www.rssd.esa.int/index.php?project=Gaia

A description of the instrument's principle may be found in Katz et al. (2004); however since then the overall payload has been modified.

More details on the determination of the dispersion law can be found in the paper by A. Guerrier (2007).

2 Need for standard stars

The RVS is a slitless spectrograph without calibration device: the determination of dispersion law and RV zero-point will rely on iterative self-calibration plus a set of reliable stable stars for which the radial velocity

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has been determined from the ground before launch with a better accuracy than the one finally expected from RVS for the brightest stars. These stars will also allow a regular check of the stability and performances of the instrument

Selection of usable objects

Two types of objects are usable:

- The best are bright asteroids:they are the only objects for which the kinematic radial velocity is known from theoretical calculations with an accuracy of a few meter/s. However they are not numerous enough, distributed only around the ecliptic, and never observed by Gaia at opposition, but at some phase angle (20 to 30 degrees). Simulations show that during the mission there will be several periods of several months without good asteroid. They remain the ultimate references.
- Bright stars with a good enough RV, selected according to the criteria listed here below. Up to now they have been taken within the following published lists: Nidever et al. (2002); Nordstrom et al. (2004; mostly CORAVEL data); Famaey et al. (2005; CORAVEL data)

The selected stars should be good references until the end of the mission (2017): bright enough, single, stable, well distributed over the sky, with already a good observational history, and selected from only a SMALL number of existing lists on a homogeneous way. The following "qualities" were required from these stars:

- belonging to the HIPPARCOS catalogue (very homogeneous selection criteria for a basic list)
- Magnitude interval: $V \geq 6$; $G_{RVS} \leq 10$, where G_{RVS} is the magnitude in the RVS band (close to I);
- Spectral types involved: F5 to K; M dwarfs; K giants are especially desirable, as they are very stable and exhibit very sharp lines; while M giants are unwanted.
- Accuracy and stability for ground-based RV: better than 300 m/s; no periodic variation or slow drift until end of mission (2017);
- No double, pulsating or variable stars (changing RV);
- Already good observational history for RV;
- No disturbing neighbours within the selection window (i.e. within 80 arcsec), with a magnitude difference ≤ 5;
- about 1000 to 1500 objects.

A first provisional basic list of some 3600 objects has been already extracted; however many have only 2 RV measurements, all of them being older than 2004, i.e. more than 12 years before end of mission. Therefore new measurements are a real must before launch, for a good selection and stability assessment. An on-purpose database has been developed for storing old and new measurements and for allowing an easy progressive selection. The present sky distribution is shown on figure 1.

3 First measurements at OHP with ELODIE and SOPHIE

Observations started in 2006 at OHP with the ELODIE spectrograph (mean accuracy: 50m/s). They are presently continuated on the new SOPHIE spectrograph, and will also involve the NARVAL spectrograph at Pic du Midi in a near future (moreover NARVAL covers the RVS spectral interval: its spectra can therefore also be used directly by the Gaia simulation groups).

The comparison with IAU standards (see figure 2) shows a very good agreement, although with a slight shift. The comparison with Famaey data (see figure 3) shows in addition the dispersion due to CORAVEL.

Asteroids brighter than $V \leq 12$ have also been observed with ELODIE and further with SOPHIE. Observed minus computed (O-C) values, corrected for the motion of the observer, are plotted in figure 4 vs. the signal to noise ratio SNR: a SNR$\geq$20 is required to get good RV measurements. In the next steps we will test possible biases in the radial velocity zero point determination due to the asteroid finite size, apparent motion and rotation.

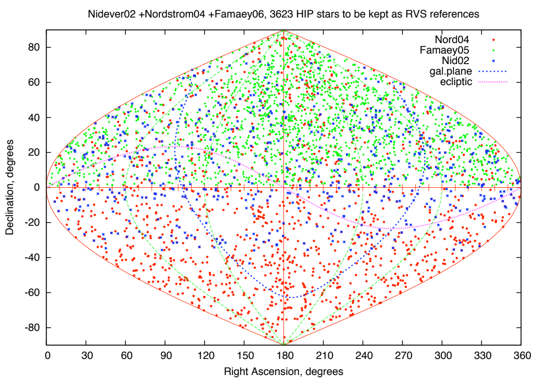

Fig. 1. Sky distribution of the present provisional star list. Some northern stars will still be eliminated

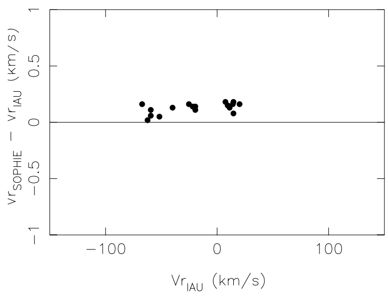

Fig. 2. Comparison SOPHIE/ IAU standards

4 Additional studies

Simulations within the Gaia DPAC consortium will allow very soon a better understanding of the limitations for star selection. In particular, the effect of permanent neighbours in the vicinity of a star has to be studied carefully: minimum acceptable angular distance and magnitude difference will be determined from numerical simulations. A first study made within the USNO-B1 Catalogue (available on-line at CDS) shows that about 20 to 30 % of the stars will have to be rejected because of disturbing neighbours.

5 Conclusion

It is absolutely necessary to use a set of calibration stars for the Gaia-RVS. Objects can be found in the existing literature, but their present data are insufficient to make them reliable objects until the end of mission. Therefore an important observational effort has to be conducted in order to acquire the relevant data before launch.

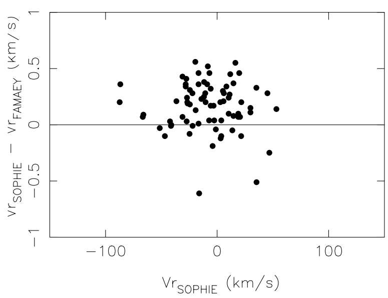

Fig. 3. Comparison SOPHIE/ Famaey-Coravel

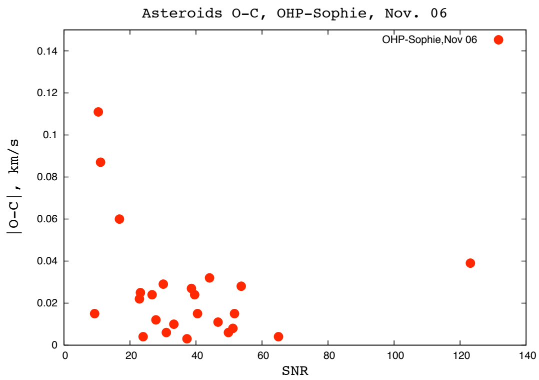

Fig. 4. Asteroids observed with SOPHIE: (observed - calculated) RV. The observed asteroids are: Astraea, Iris, Irene, Melpomene, Kalliope, Phocaea, Laetitia, Hestia, Leto, Diana, Klotho, Liguria, Patientia, Interamnia

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7 The bibliography

References

Famaey, B., Jorissen, A., Luri, X. ,et al., 2005, A&A, 430,165

Guerrier, A., Katz, D., Turon, C., et al., 2007, this issue

Katz, D., Munari, U., Cropper, M., et al., 2004, MNRAS, 354, 1223

Nidever, D. L., Marcy, G. W., Butler, et al., 2002, ApJS, 141, 503

Nordström, B.; Mayor, M., Andersen, J., et al., 2004, A&A, 418, 989