First meeting on ground-based observations for Gaia

Minutes

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Abstract

This meeting has been organised in order to define a coordinated framework for the ground-based observations that are necessary to prepare GAIA. A summary of requirements is presented. An observing plan has been drawn that could meet all those requirements, in the most efficient way, without duplication of efforts.

The presentations from the meeting are available via the GaiaWiki. Other relevant documents are available on Livelink and are cited below.

1 Participants

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2 Background

CS recalls that the need for Ground-based observations in support of Gaia has been recognised from the beginning as an integral part of the processing of the Gaia observations. Several early ICAP documents are available. A preliminary list of requirements has been compiled in GAIA-C8-TN-L3AB-CS-001. Now the time has come to start the detailed specification of the observations needed. Items to be discussed in this meeting are:

- What are the detailed requirements from the various CUs in terms of number of stars, magnitude range, AP range etc?
- Which observatories/telescopes are suited for the observations?
- How can the work be made most efficiently without duplication?
- Is it relevant to link the calibrations to a science case?
- Which data is already available in archives?
- How is the obtained data going to be made public?
- Should high level agreements be sought with observatories?

3 Summary of requirements, by CU

3.1 CU4 (Thuillot)

The asteroid part of CU4 is for the moment the only part which has specified their plans for ground-based observations in support of Gaia. In difference to the other CUs, they need no direct calibrations, but rather complimentary or follow up observations.

Task GWP-M-440-45000 (Follow up and on alert observations) requires observations of fast moving objects in order not to loose them. Gaia alerts will be used to trigger observations. Follow up observations can also be used to determine the rotation of asteroids. OHP will function as a central hub in a worth-wide network of 18 prospective observatories. The observations will be carried out using small 0.5m class telescopes. A planning meeting is scheduled for November in Paris, and will also be discussed in the upcoming symposium on mutual events of the Uranian satellites. It is for the moment unclear how many NEO there will remain to be discovered by Gaia considering the discoveries to be made by Pan-Stars and LSST.

Task GWP-M-440-35000 (mass determination) : of the known 340000 asteroids, only 40 have masses known better than 50%, and only 20 with better than 10% per cent. Gaia will obtain good masses for 100-200 asteroids, but the sampling will be bad especially in the beginning and end of mission and for some objects even during mission. So GB astrometric observations will be needed before, during, and after the Gaia mission.

The observation will need CCD astrometry and photometry. No big pre-launch observation program is planned.

3.2 CU5 (Cacciari)

The ground based absolute calibration part of CU5 is handled by DU13 and is already in an advanced stage of preparation. The general requirements is presented in GAIA-C5-TN-OABO-MBZ-001, and the details of a proposed pilot program in GAIA-C5-TN-OABO-LF-001. Things being discussed and still to be finalised include: how is the selection of spectrophotometric standard stars (SPSS) to be made; number of stars, spectral types, magnitude range, observation mode, database, definition of pilot program, how observations are to be made (definition of a observation protocol).

CU2 (Barcelona) has made simulations (GAIA-C5-TN-UB-JMC-0.39-1, draft) showing the required observation time to reach the tentative S/N=100 for RP/BP considering crowding for various spectral types and magnitudes. Gaia will obtain S/N=100 for 80 transits at 330nm only for V<13 (TBC).

The intended range of magnitudes for calibration stars is 10<V<14 using nearly featureless spectra mainly of WD and SD. Brighter stars may be needed to test the gating, as well as fainter stars. Crowded fields have to

be avoided. Extinction determination has to be addressed. Suggestion to contact CU8 (Strayzis) was made, since they will work on DIBs.

Primary standards may be selected from the HST CalSpec list (see Bohlin 2006 and references therein), but since this includes less than 40 stars, more stars are needed to reach the estimated 100. The input database is under construction. The exact number of calibration stars needed is TBD based on the results of the pilot program and further simulations.

The observations can be carried out in two ways:

- Pure absolute spectrophotometry covering 330-1050nm with R 500-1000, S/N $\sim$100. Since this is very hard to perform, possibly it has to be complemented with the second method.
- Spectroscopy + photometry with 1% accuracy in flux covering UVBRI (perhaps fewer bands will be needed)

The purpose of the pilot program is to test the procedure and methods of observations and quality of sites. It will also start to build up the database of standard stars. Proposals will be made to Calar Alto and TNG this fall. ESO will be considered in spring. The possibility of ESO DDT was mentioned, as well as the CFHT for absolute photometry.

Contacts will be taken with the Adelman project to evaluate possible overlap since that project mainly considers bright V<10 stars.

A call will be made to the Gaia community to suggest suitable red standards (metal-poor F0 and later).

3.3 CU6 (Soubiran)

GWP-S-640 is concerned with the determination of the radial velocity zero-point using stars and asteroids. A stellar grid is to be defined consisting of 1000-2500 6<V<10 FGK stars. The primary stars are to be stable at the 300m/s level. There must be a few observations per star to verify the long term stability. Secondary standards are to cover fainter stars and other spectral types and may be partly drawn from the RAVE catalogue. A S/N of about 20 is required. Asteroids are excellent sources to calibrate the zero-point because their radial velocity can be computed with uncertainties below 1 m/s, but there are few bright ones and they have low sky coverage. They

will be observed together with stars to study possible systematic effects.

Observation time is expected to be 5-10 nights/year with SOPHIE and/or NARVAL at OHP and possibly 3 nights/year at CORALIE. FEROS could also be considered.

The task has three active members and three collaborators totalling 0.5 FTE/year.

3.4 CU7 (Eyer)

Tasks and responsibilities has been assigned, but handling of special objects are still in evaluation. Ground-based observations are not yet defined. Possible tasks are:

- prepare data processing of colour variations before launch
- quality assurance of interesting objects before release of catalogue
- follow-up on Gaia observations during and after mission
- variability monitoring of SPSS prospects

The observations will mostly use small <2m class telescopes using many observations and wide fields covering JHK photometry and spectroscopy.

Contacts with prospective observatories made, no results yet and no programs started.

Existing data in Hipparcos,ASAS,NSVS,OGLE,EROS,MACHO,RAVE and SDSS will be used.

3.5 CU8 (Frémat)

ESP handles all 'extreme' stars, not well parametrised by GSP-phot. Such stars are poorly modeled so that real data is needed to see how they will look like in the Gaia eyes, and how they will be regognised by the DSC. Real data is also to be used to improve existing models. New data are needed for the calibration of RP/BP and the validation of synthetic atmospheres, as well as the study of Ca triplet for activity indicator. Lots of catalogues are available, not all in electronic format. Observations of O and WR stars are ongoing. Input list of anomalous abundance stars with V>10 is in preparation in Vilnius, with good manpower situation, but little money

for travel. They will need good observatory site. C. Martayan is preparing an input list for emission line stars. A database of Be stellar spectra is under developement in Meudon, but not centred on Gaia. This task may use AURELIE,FEROS,EMMI,SARG,NARVAL,FLAMES and several small telescopes. No estimate of stars yet.

3.6 CU8 (Thévénin)

Summarised what training data will be needed in CU8 consisting of ground-based observations and simulations. Mentioned an ambitious interferometric programme to measure stellar radii of fundamental stars to set the effective temparature scale.

3.7 CU8 (Heiter)

Presented a study of benchmark stars which are to be studied in detail to improve model atmospheres of FGK stars. This will test the effects of 3D and NLTE and can then be used as an indirect calibration of Gaia (approach 1). Astrophysical parameters are to be determined independently from models as "fundamental values".

In a first step, 8 stars have been selected. Half of Solar metallicity, half metal poor in four different "boxes" of stars: MS F-stars MS,SG and RG G-stars. Most parameters are not fundamental yet. Data are available on GaiaWiki and on a Uppsala web-page. Will propose new observations and get homogeneous data. May use Adelman ASTRA spectrophotometric data and need also very high resolution (R $>$ 120000) to compare SEDs and lines to predictions of Uppsala models. Work independant of Gaia as improving stellar models is more general.

3.8 CU8 (Korn)

Emphasised the need to present a coherent concept to TACs, and the many types of data needed (hi/low resolution spectroscopy , photometry, spectrophotometry).

Two ways possible to get the needed observations:

- present a good (autonomous) science case
- supplement this with a dedicated program. This may be in the form of a large program, perhaps after a ESA-ESO agreement

Also made a presentation of a diffusion project of NGC 6397 and NGC 6572 observed with UVES-FLAMES which may also be useful for Gaia, in the sense that it would improve our knowledge of the abundances in stars, thus models and synthetic spectra. Needs complementary observations of the second kind.

3.9 CU8 (Soubiran)

Task GWP-S-811 is to provide a grid of reference stars for GSP. For GSP-Spec, bright 6<V<10 stars are needed, these may be present in archives. For GSP-Phot, fainter 10<V<18? stars are needed. These can be selected in open or globular clusters or in Gaia "test-fields". High priority has to be given on single FGK stars. A database project has been started to incorporate radial velocity and astrophysical parameter data. COROT has also a database, with one part public, another one on restricted access, which is was proved to be very useful.

3.10 CU8 (Holmberg)

DSC and GSP-phot are currently being trained with synthetic spectra, but it is important that the algorithms work on realistic data. It is strongly recommended that training data include real SEDs of all kinds of objects that are classified by DSC, and all kinds of stars that are parametrized by GSP-phot.

4 Summary of requirements, by type of observing programme

Only observations to get urgent and mandatory calibration data are considered in the following. They include the RP/BP flux calibration, radial velocity zero point and AP reference stars/objects for DSC, GSP-Phot, GSP-spec, ESP. Other observations that will improve the interpretation of Gaia's data but not with a direct impact on the processing (CU4, CU7 for instance) will be considered later and separately.

4.1 Spectrophotometry, or low spectroscopy+photometry, or combination of both

1. BP/RP flux calibration N=100 to ? V=10-14 (with some stars beyond the edges)

2. SEDs of AP fundamental stars N=10 to 30 ? V=0-8

3. SEDs Em + anomalous abundances N=50 V= ?

4. Grid of faint AP reference stars N=200 to ? V=10-14

Programmes 4,3 should be merged to 1 but will represent a substantial effort in observing and reducing the data. Manpower has to be adequate to the task. Common targets must be searched. Programme 2 can be made independantly of Gaia, see collaboration with ASTRA One instrument in south (EMMI ?) and two in north appear sufficient (TBC after pilot program).

4.2 Hi res spectroscopy (including RVS range)

1. RV zero point (low S/N) N=1000 to 2500, V=6-10

2. bright AP reference stars for GSP-spec (high S/N, training data + determination of AP) N=200 to ?, V=6-10, select also absorbed stars for DIBs

3. Faint AP reference stars for GSP-phot (observed also in spectrophotometry) N=200 to ?, V=10-14

4. Em + anomalous abundances (observed also in spectrophotometry) N=50, V<10, follow-up

5. faint anomalous stars

Programmes 1,2 and 4 can be done on same instruments, NARVAL + FEROS for instance. A common proposal should be written. COROT also has a large pg on FEROS. see OES ?

Programmes 3 and 5 require UVES or UVES/FLAMES. If necessary, Science cases could be related to the homogeneous observation of clusters giants + dwarfs to test evolutionary models, test fields in different stellar populations, search for solar analogs. Very hi res (R>120000) is required for fundamental stars. This is however a proposal not directly related to calibrations for Gaia, even if this work will benefit to it. HARPS or SARG will be requested.

5 Summary of requirements, by Observatory

5.1 ESO

We will present to ESO a long term programme on 5 years minimum. It requires more flexibility than an usual large programme (4 semesters). There exist agreements between ESA and ESO (ex XMM Newton). DPACE should negotiate such an agreement on Gaia in order to get an official document of endorsement for TACs. The group agrees on the fact that it is very difficult to find an exciting scientific justification other than Gaia itself to obtain calibration data. DPACE should convince ESO Director and TACs that the following programmes are necessary and will also be useful for a wider community. This work to prepare Gaia will also be a service to the community, in the form of science ready data in the VO for instance.

1. large programme spectrophotometry and/or low resolution spectroscopy (EMMI or FORS2) : calibrations of BP/RP + AP for GSP-Phot and ESP, number of nights per year : minimum 10-15 nights on EMMI, 3 nights if FORS2 (see overhead)

2. high resolution for bright stars : FEROS, 6 nights/yr should be sufficient because there are already much existing data, ESO time could be combined to MPG time (see with CBJ)

3. UVES-FLAMES : 3 test fields + 2 OC (including M67 with solar analog identification) + 3 GC (47 tuc, NGC 6397, NGC 6752) + add other clusters to sample the metallicity range, 3 wavelength ranges + 2 kinds of exposure (short + long), 3 nights per year might be sufficient. Is it possible to obtain calibration data without adding science ?

5.2 Other observatories

Other observatories and national facilities have to be contacted. For spectrophotometry and low resolution spectroscopy, several sites are forseen :

- TNG : Italy (CC)
- Calar Alto : Spain (see C. Jordi) + Germany (see CBJ)
- Nordic Telescope : Dannemark (JH sees with J Andersen)
- INT : S. Trager + Spain

The CU5 pilot programme will be submitted on TNG and Calar Alto anyway, before any agreement is negotiated. Submission to Calar Alto done on Sept. 15.

For high resolution spectroscopy, french telescopes will play an important role. Y. Frémat mentions the Hermes echelle spectrograph build by Belgium in 2008 in la Palma, including RVS range. There are also Tartu observatory, Ondrejov Observatory, SARG on TNG and several other instruments that have been mentioned previously. However it is preferable not to have too many different instruments because calibrations should rely on homogeneous data.

6 Actions

1. Minutes of the meeting are written by JH and CS with input of all (ASAP). This will be an input for the next DPACE meeting on Thursday 21 September. There will also be an input from LE and F. Mignard

2. A detailed report has to be written for the Livelink by the end of october (CS + all). It should also communicate to GAIA community about proposals that present observations for GAIA. There are two cases : (i) calibrations, absolutely necessary and coordinated by our group and (ii) science cases that will improve the interpretation. We recommend that the former use a standard (and copyright) title e.g. "Gaia Calibration Working Group: ...", to identify unambiguously our calibration program.

3. FT will contact F. Mignard on monday to complete the document for the answer to AO with a specific paragraph on GBOG

4. See what are the requirements for QSOs, galaxies, WD, binaries... : DSC must have training data (CS on monday).

5. On going selection of stars and search in existing data should be better organised. SPSS are searched by CC and collaborators with input from AK for metal-poor late-type stars. About fundamental stars, UH will require input from all by email. Work on AP reference stars is coordinated by CS, with help of UH for FGK types, by YF for other types. FT and AV participate to the search of relevant clusters and test fields. RV standards are selected in a dedicated CU6 WP coordinated by CS in collaboration with F. Crifo and G. Jasniewicz.

6. Coordination, proposals. Contacts from individuals to national facilities listed above should be done by dec 2006. The result of the 1st submission of the CU5 pilot programme should be known by Christmas. Proposals on fundamental stars and GC will be made by AK et UH group in oct 2006 and march 07. CS+CN will write a common proposal for NARVAL and SOPHIE about RV standards, bright AP reference stars of FGK and hot spectral types (oct 06). The group has to think about the spring proposals in 3 parts, (i) 1st run of spectrophotometry at ESO, (ii) 2nd application for the campaign, after pilot one, at Calar Alto and/or Canaries, (iii) ESO hi res spectro. Another meeting should be organised in early March 07 to coordinate the writing of proposals, depending on the results of the negotiations. CC is responsible of all the spectrophotometric observations (with input for those needed for AP). Another meeting may be foreseen in May-June, after we get the data from the pilot programme, to decide about the practical aspects and coordination of the observations and reductions (manpower assessment, tasks). CS is repsonsible for high resolution spectroscopy with help of CN. If a scientific case has to be made to apply on UVES-FLAMES, FT will the coordinator of the programme, which should be splitted into test fields, OC and GC.