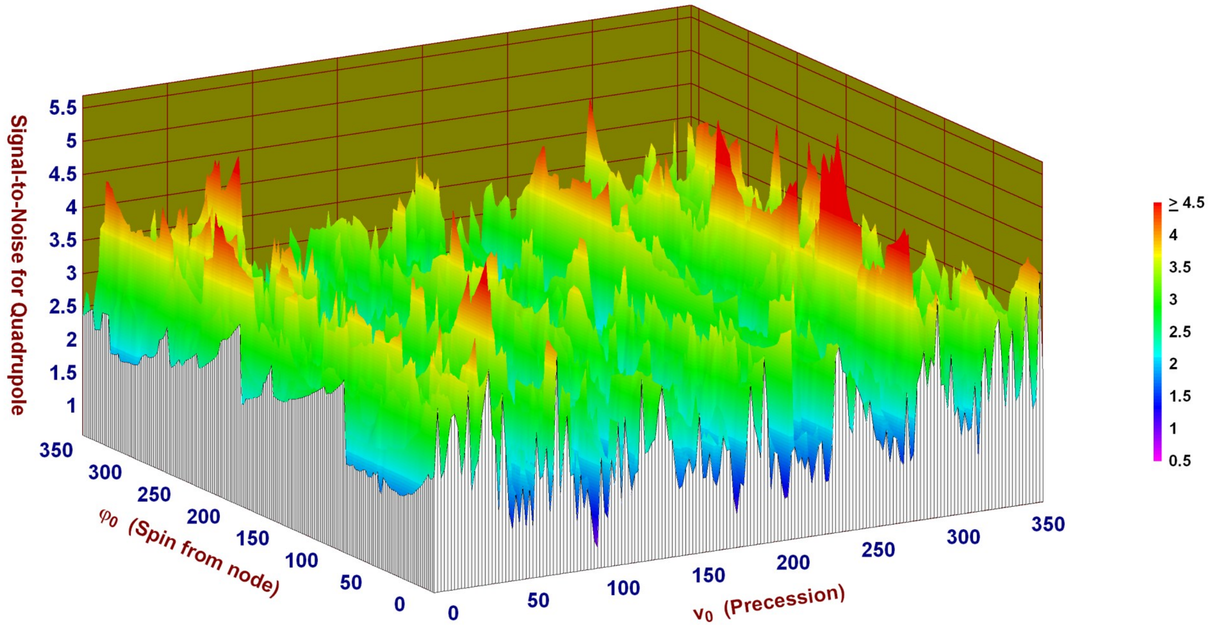
Newsletter 20

3 MAY – 2013



Detection of the quadrupole light deflection by Jupiter as a function of the initial conditions of the scanning law. The efficiency is given in Signal/Noise or equivalently the detection of the quadrupole effect at 2, 3, 4 .. sigmas. This is for Jupiter observations between 2014 and 2019, assuming stars can be measured as close as 5 arcsec from the limb of Jupiter. One sees that the choice of the precession phase is the most important parameter with few good values and many very bad values.

IN THIS ISSUE:

Editorial by DPAC chair, Anthony Brown

When you receive this newsletter the third operations rehearsal for DPAC and the SOC will just have finished, while the Ground Segment Readiness Review is ongoing. The Mission Operations Center in Darmstadt has also started an extensive series of simulation campaigns in order to get ready for launching and operating Gaia. September is rapidly approaching!

On the spacecraft side everything is progressing nominally. From the thermal vacuum/ thermal balance tests it is now clear that the optical alignment of the Gaia telescopes has been performed very well. The payload and service module have been integrated which can be seen in the impressive pictures (see link on the Gaia website) obtained during the weighing of the spacecraft at the test facilities of Intespace in Toulouse.

The diagram above illustrates one of the first DPAC activities which will take place after launch, which is the optimization of the Gaia scanning law. The initial conditions of the scanning should be such that Galactic plane scans are avoided during the period that the Rosetta mission is active, and that favourable configurations are achieved for observing light bending by Jupiter.

DPAC

A. Brown

The composition of the DPAC project office will change over the coming months. The project coordinator, Emmanuel Mercier, will leave DPAC as of July 1st to start a new job. His position will be taken over by Sebastian Els and the transition has already started. I want to thank Emmanuel very much for all the valuable contributions he has made to the DPAC effort and wish Sebastian the best of luck in his new role.

DPAC has been enlarged with a new Coordination Unit, CU9, following the endorsement by ESA's Science Programme Committee of the proposal for the development of the Gaia archive access element. CU9 will have its kick-off meeting on June 3 and 4 in Barcelona. Xavier Luri was confirmed as the CU9 leader by the DPAC Executive. He thus stepped down as CU2 leader. The latter position was taken over by Carine Babusiaux. I wish them both all the best in their roles as CU leader.

A lot of activity over the past and coming months concerns the preparations for the Gaia commissioning phase. The fifth Initial In Orbit Calibration (IIOC) workshop was held at MSSL in early March. At this workshop the procedures for uploading calibration activities to the Gaia on-board time line were discussed. The IIOC team, also known as the Payload Experts Group, is now working out all calibration activities in detail down to the level of generating pseudo code for the on-board operations. This pseudo code will be converted by the SOC calibration team into detailed flight control procedures to be uploaded to Gaia.

In addition a workshop on the commissioning time line was hosted by Astrium on their premises in Toulouse. The SOC calibration team and the DPAC IIOC team heard details of what will happen (and when) during commissioning, while Astrium was informed of the detailed plans that DPAC and SOC have for the initial checking out and calibrating of the Gaia payload. Over the coming months DPAC, SOC, MOC, and Astrium will work closely together on the details of the commissioning plan. Toward the end of commissioning the payload experts will produce a detailed assessment of the actual scientific performance of Gaia. This will form the basis of one of the first publications on the Gaia mission, detailing its actual state and providing an updated science performance budget. Something to look forward to!

The third operations rehearsal (OR3) is well underway as I write these words. Operations at DPCE are running much more smoothly than during OR2 and the payload experts group is settling more and more into its role of supporting commissioning. During OR3 the daily Solar System Objects processing chain and the Science Alerts pipeline will be operated for the first time. The observations of Planck (to simulate the ground based optical tracking of Gaia) are again taking place, this time involving, apart from the Liverpool Telescope on La Palma, also telescopes from the Las Cumbres Observatory network in Texas, Chile, and South Africa.

Words of Gaia: QUASAR

F. Thévenin

Quasar: A name coined in 1964 from "quasi-stellar radio source" shortly after the identification of these very energetic and distant sources which have nothing to do with stars.

A puzzling discovery

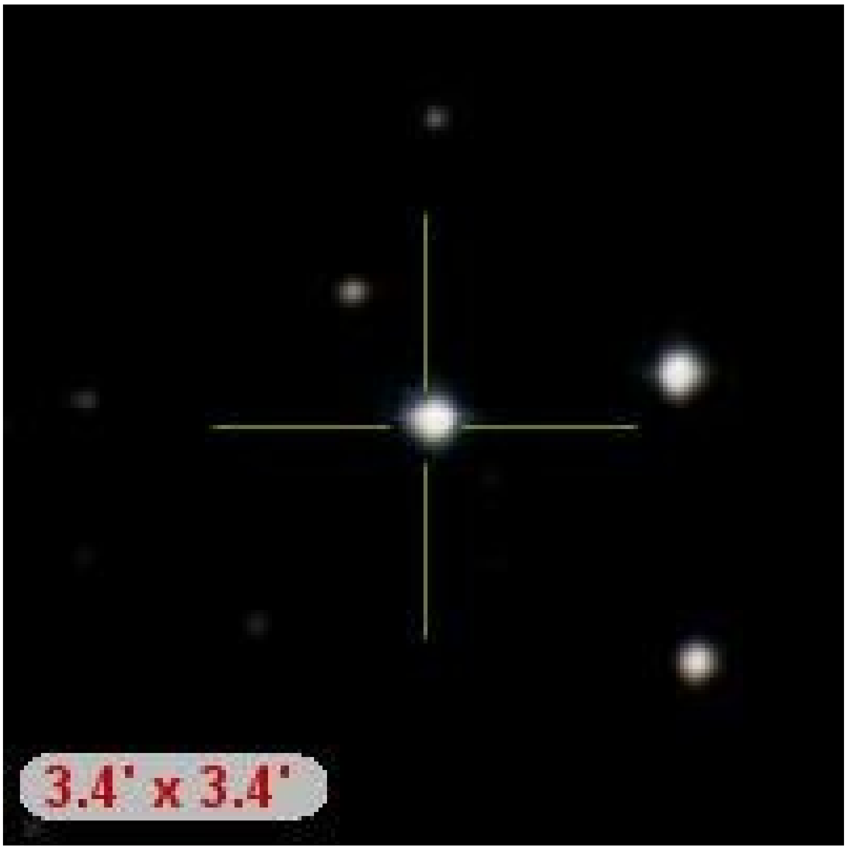
Point-like radio-sources were recorded by radio telescopes in the late 50s but none could be tied to an optical counterpart until 1962, when Cyril Hazard and John Bolton succeeded in ascertaining accurate astrometry thanks to an excellent timing of several occultations of 3C-273 by the Moon, observed with a radio-telescope. This allowed to find quickly and with great certainty an optical counterpart whose spectrum was readily obtained by Marteen Schmidt in 1963 with the 200-inch at the Mount Palomar, the then largest optical telescope.

Their nature was puzzling, and still largely is, because looking like a point-source star, blue, but also being an extraordinary powerful radio source with an optical spectrum filled with emission lines and resembling nothing known at that time. After a long thinking, Schmidt recognised the signature of strongly redshifted hydrogen lines (in fact this was only z =0.16, a nearby quasar for today standards). Nothing could be said regarding their distance and size, although the variability in flux discovered soon after constrained their size to an upper limit of about one light-day, that of a very compact object if it belonged to the extragalactic world.

The Gaia Reference Frame

Their distance has been the subject of long debates, even if the redshifts were interpreted as a cosmological redshift, placing quasars as the most powerful radio-sources in the Universe. Then many quasars started to be discovered thanks, in particular, to catalogues of blue stars. The conviction that they are the visible nucleus of active but invisible host galaxies emerged rapidly as a unifying model; a connection with the Seyfert's galaxies was then easily made. To generate the fantastic energy of a quasar only one object could be imagined at the centre of it: a giant black hole swallowing a few stars per year to sustain its radiation.

Gaia will observe all of them, approximately 500,000, up to the 20th magnitude, the first such all-sky survey. Because quasars are extremely distant, very small in angular size, with no visible relative motion, they are used as reference points to establish the primary grid to materialise coordinates on the celestial sphere. Gaia will use the brightest ones to build its inertial reference frame to which all the stars and solar system object will be referred to. At the end of the mission this frame should become the first ICRF (International Celestial Reference Frame) in the optical wavelengths.

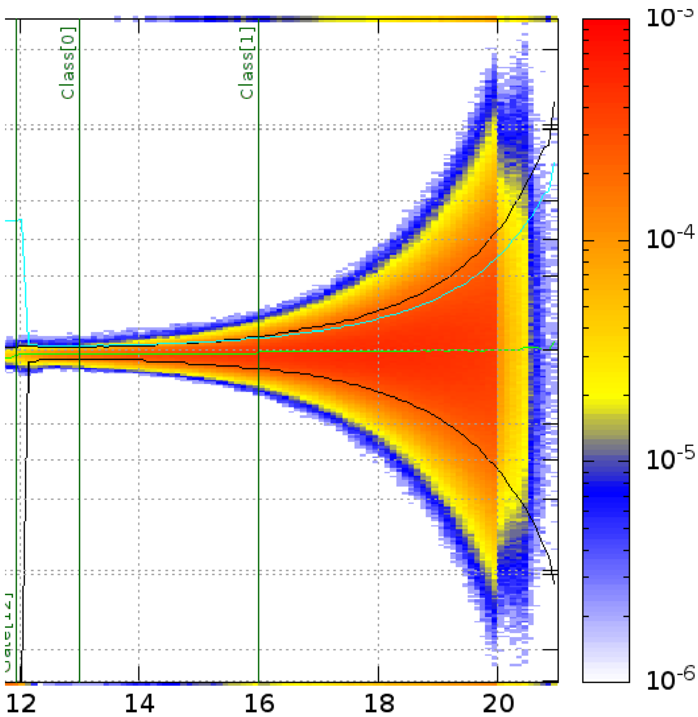


This optical image of 3C273 reveals the stellar appearance of a quasar. The quasar is at the center bordered by two field stars of similar magnitude.

Coordination Unit 3: From pixels to stars, and from centroids to parallaxes

Uli Bastian

With 105 active members and three associated data processing centres (DPCs), CU3, the "Core Processing'' unit is the largest of DPAC's nine units. Its primary tasks are:

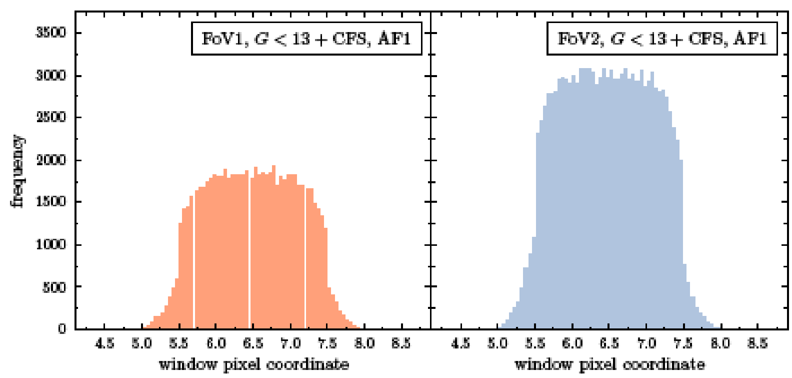


Satisfactory distribution of actual centroid errors (IDT minus simulated "truth") versus G magnitude. Note the logarithmic colour scale. The boundaries of the picture are at ±9 mas.

- to receive, sort and reformat the raw telemetry for the rest of the consortium (IDT),
- to identify the observed sources on the sky, and to assign the 10^{12} raw CCD observations to the 10^{9} inferred sources (IDT and IDU),
- to determine image parameters, mainly the centroid location and the brightness (IDT and IDU),
- to do a permanent, quick, in-depth continuous verification of instrument health and data quality (FL),
- to make Gaia data reductions consistent with and applicable to General Relativity (REMAT),
- to derive an astrometric model and an astrometric calibration for Gaia, and to compute the basic astrometric parameters – i.e. positions, proper motions, parallaxes - for all stars (AGIS),
- to independently verify the astrometric base solution and astrometric modeling (AVU),
- to provide DPAC with supplementary data such as time calibrations, solar-system ephemeris, ground-based optical tracking, an a-priori star list and QSO catalogue, and others (AuxDat).

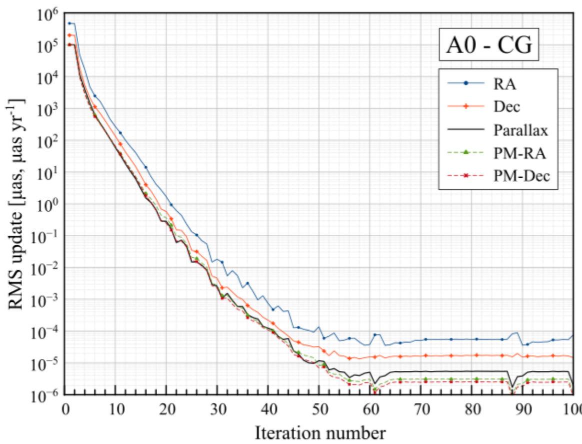
The abbreviations in brackets refer to the division of CU3 into the top-level workpackages Initial Data Treatment (IDT), First Look (FL), Astrometric Global Iterative Solution (AGIS), Intermediate Data Updating (IDU), Astrometric Verification Unit (AVU), Relativistic Modelling and Tests (REMAT) and Auxiliary Data (AuxDat).

The biggest portions of CU3 members reside in Italy, Spain, Germany and France. The most remote member is located in Brasil. An extremely important and difficult DPAC task that truly belongs to the "core processing'' for Gaia is formally developed outside CU3: The modeling and calibration of the shape of the astrometric images, in particular of the cosmic-radiation-induced damage to them. This is taken care of under the auspices of CU5, mainly in the United Kingdom.



Correct distribution of GASS-simulated centroids within AF1 windows, as demonstrated by FL. The difference between the two fields of view indicates the GASS bug reported in BAS-040.

Rapid and complete convergence of AGIS (from LL-096)



Gaia at the Ondřejov Observatory of the Astronomical Institute AS CR

Pavel Koubský

The Astronomical Institute of the Academy of Sciences of the Czech Republic (AS CR) is the main astronomical facility of the country (http://www.asu.cas.cz). It is located on two sites, one in the city of Prague, and the other at the Ondřejov Observatory, 35 km outside the capital. The Observatory started as a private facility more than one hundred years ago. Eighty-five years ago, the Observatory was donated to Charles University in Prague. Reasearch fields of the Institute cover solar and stellar physics, minor bodies in the Solar System, planetary systems, galaxies and relativistic astrophysics.

The Ondřejov Gaia Team (from left to right): Jan Fuchs, Pavel Koubský, Viktor Votruba, Lenka Kotková

Our involvement in Gaia...

The Gaia project has been of great interest to the Czech stellar community since 2006 on the occasion of the XXVIth General Assembly of IAU held in Prague where this space mission was presented. Shortly afterwards consultation with number of scientists involved in Gaia preparation started. In 2007 a successful ESA PECS (ESA Plan for European Cooperating States) proposal entitled "Czech participation in the Gaia project" was submitted. The main tasks of the project were: ground based support for Gaia, specific object studies of Be stars, cataclysmic variables and optical counterparts of high energy sources, spectral variability detection using simulated low dispersion Gaia data, and software contribution. The original team created in the stellar department of the Ondřejov Observatory has changed since 2007, together with the tasks. The funding of the PECS project ended in 2012 and the team is now supported by the Institute.

Today, the main contribution of Ondřejov Gaia Team to DPAC concerns CU7. We are involved in the automatic classification of light curves, paying particular attention to Be stars in surveys like OGLE, EROS or MACHO. Since autumn 2012, ground based photometry of selected targets from these surveys have been secured with Danish 1.54m Telescope at La Silla, Chile. The telescope equipped with DFOSC used in the photometric mode has observed some fields for GSEP (Gaia South Ecliptic Pole) and in future will participate in Gaia Science Alerts too.

.... and outside Gaia.

Aside from this DPAC activity, parallel observations of Be stars in H alpha and Gaia RVS regions using the 2m telescope at Ondřejov have been secured. The survey of about 150 Be stars clearly shows the correspondence between the H alpha emission profile and Paschen hydrogen lines in the RVS region. A preliminary report entitled "High resolution spectroscopy of Be stars for Gaia" has been prepared.

Optimisation of the Scanning Law for a Relativity Experiement.

F. Mignard

Gaia comes with a wide range of scientific objectives bordering its core astrometric science, among them several tests of the relativistic gravitation theory. Here I consider the detection of the minute bending of the light rays by the giant planets.

Relativistic light bending

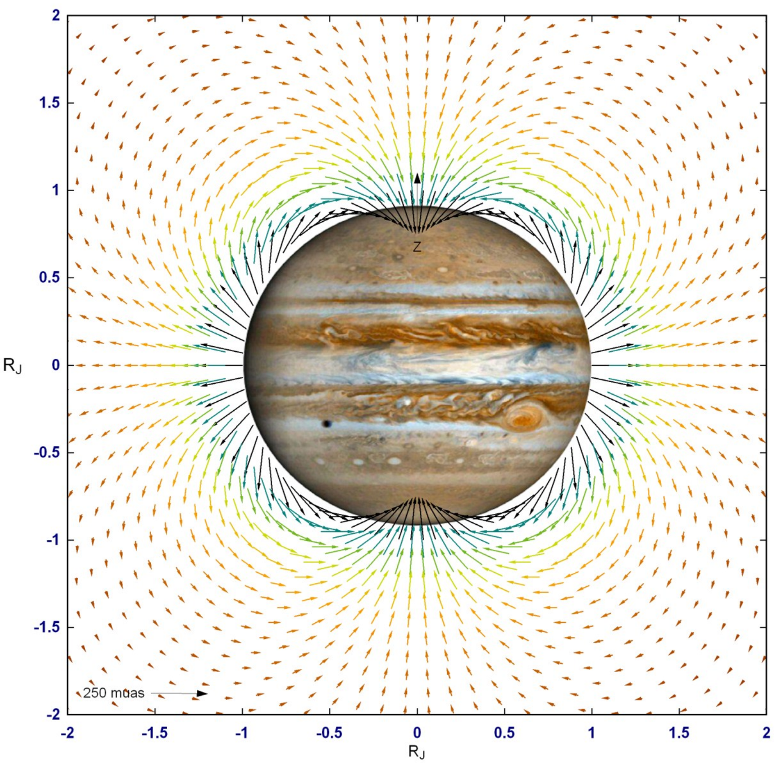
The bending by the Sun predicted by A. Einstein has been measured as early as 1919 in a much heralded experiment during a solar eclipse. Gaia will see this effect virtually on every star whatever their angular distance from the Sun, as the effect is very large for Gaia accuracy standards. It reaches 4 mas at 90 degrees from the Sun.

Similar bending, but much smaller in magnitude, will show up near the giant planets, in particular near Jupiter, the most massive planet in the solar system. Taken as a point mass or a perfect sphere, the bending of a grazing ray (a ray joining a star to an observer and passing just above the surface of the planet) amounts to 16 mas and decreases linearly with the angular separation between of the star and Jupiter. This will be measured and astrometric observations near Jupiter will be corrected for this effect. However the challenge is not there: Jupiter's overall shape departs significantly from a perfect sphere and has a marked oblateness, about 20 times larger than the Earth's. This causes the light deflection not to behave like for the Sun and to exhibit a non radial component superimposed to the point mass deflection of 16 mas. The contribution of the flattening to the light bending tops at 240 muas for grazing rays and decreases quickly with larger separations as the third power of the separation. Therefore for a star seen at one Jupiter radius from the planet's surface this drops to 30 muas and to a mere 4 muas at two radii. The quadrupolar (the contribution of the flattening) bending field of Jupiter is shown in Fig.1, where the scale of the arrows is shown on the lower left.

Scanning initial conditions

With the method adopted for Gaia to scan the sky, Jupiter will be within one of the Fields of View about 65 times over 5 years. Jupiter is not observable as a source, being much too large and bright to be detected and measured. But the surrounding stars will be normally observed even at few arcsec from the planet limb. The closer a star is to Jupiter, the stronger the bending and it observable signature. Since the scanning law has two free parameters (the two initial phases, one for the precession of the spin axis and the other for the spin phase itself) there is a possibility to choose their values so that the number of Jupiter transits is larger than average and occur when bright stars are in its immediate vicinity. The merit of a particular initial condition is measured by the level of detection (1,2 ... sigmas) of the quadrupole factor in the light bending as illustrated in the front page of this issue. The package will be run by SOC quickly after launch to find the best intitial conditions for the scanning law.

This work is shared between Nice (F. Mignard, Ch. Ordenovic), Torino (U. Abbas, M.T. Crosta, M. Lattanzi), Dresden (S. Klioner) within the group REMAT of the CU3 and has benefited also from contributions by J. de Bruijne (ESTEC), A. Mora (ESAC).



Quadupolar relativistic light bending by Jupiter in the plane of the sky, shown as the apparent displacement of the stars. The axis of rotation of Jupiter lies in this plane in the z-direction. The largest deflection is 240 muas for grazing rays and the magnitude decreases as the third power of the distance to Jupiter centre. Gaia will observe the effect on bright stars seen close to the limb of Jupiter. The typical angular radius of Jupiter is around 20 arcsec.

GBOT Data Storage and Processing Center

Sebastien Bouquillon (for GBOT)

The GBOT* group provides optical tracking of the Gaia satellite, which means daily observations of Gaia on a small worldwide network of 1-2 m class telescopes for the whole of the mission. The requirements for the accuracy of the satellite position determination is 0.020” *(for details on the reasons for optical tracking see the DPAC Newsletter#2).*

To achieve this goal, the GBOT team faces several challenges: observatory recruitment, determination and testing of observational procedures, extraction of the Gaia position from the images and the organisation & storage of all GBOT observations and related meta-data. A sub-group – the “GBOT Data Storage and Processing Center” based at the SyRTE department of Paris Observatory – is in charge of providing scientific tools for this process during the mission.

The framework

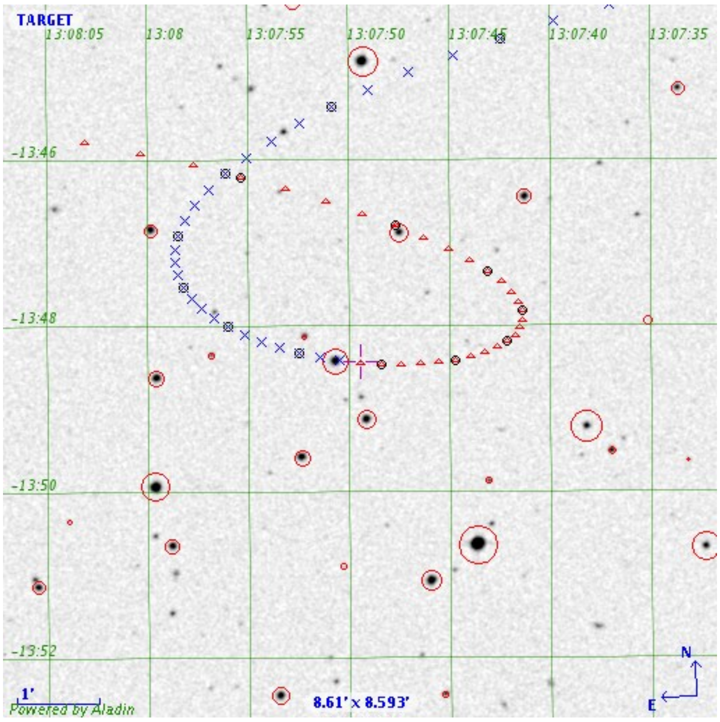
First comes the “FoV-Maker”; this web interface makes available Gaia topocentric ephemeris and the field of view to the participating observatories *(see figure)*. As we need daily observations, this interface must be always accessible and, for this reason, we have mirrored it in Heidelberg. *(http://gbot.obspm.fr/fov/).*

Then there is the “GBOT Reduction Pipeline”; this software extracts the Gaia position from the observations. This is an in-house software without 'black-boxes' on which we have total control. Software development began in 2009 and the package is now operational.

The successive steps are: (1) ingest images from the various telescopes and bring their meta-data into a common format; (2) detect and extract from the images the sources and other data (background, characteristics etc); (3) identify the detections with a reference catalogue and perform an astrometric reduction; (4) determine the position of Gaia; together with a quality diagnosis. The main challenge is to reach an astrometric accuracy better than 0.020” every day, regardless of the differences between the observing conditions, like the number of field stars or the presence of the Moon nearby. The astrometric quality of the pipeline will continue to be checked and improved during the 5 years of the Gaia mission. This pipeline has been used for other purposes such as the determination of asteroid coordinates and photometric light curves. *(ftp://gbotone-se.obspm.fr/pub/GBOT/GBOT_PIPELINE/).*

The GBOT DataBase

The maintenance, management and manipulation of this large amount of data from diverse sources require the use of a dedicated database system. Another important reason for preferring a full-fledged database system over other solutions is because after the operational phase of Gaia a final re-reduction must be carried out with the Gaia results as the reference catalogue to achieve the maximum accuracy. For 5 years, the data volume will be up to 10 TB and we have adopted the SAADA front end and a MySQL DMBS. The database development started in 2011 and it is currently operable, although not yet fully optimised. The database will receive, ingest and store all data, and meta-data, such as reduction results and logs, ephemerides, etc. The reduction software can be run from the database, and results are extracted into the formats required for delivery to ESOC. Additionally, as with all other parts of the Gaia project, all data and information used for GBOT must be archived so that it can be accessed later at any time.



A Typical field of view for a spacecraft in L2 (here Planck) built by GBOT. The crosses are the positions of the spacecraft sampled every minute. The stars in the red circles are the reference sources available to reduce the frame.

* GBOT: Ground Based Optical Tracking

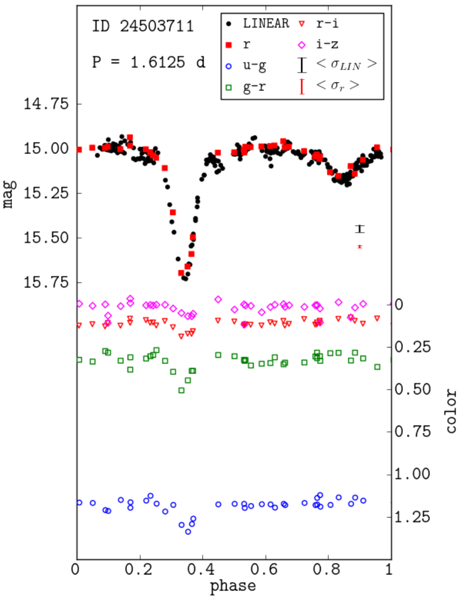
PhD Corner: Lovro Palaversa, Geneva Observatory

Lovro is a Ph.D. student within the GREAT-ITN network, working in the WP4: The Stellar Constituents of the Milky Way, supervised by Laurent Eyer.

His work focuses on variable stars, their classification and use as distance indicators.

Lovro is working on classification of variable stars from the time series acquired by the LINEAR asteroid survey, supplemented by SDSS, 2MASS and WISE data. Exceedingly pure classification of over 7,000 variable objects found in this 10.000 deg^2 area covered by this catalogue can be used as a machine learning training sample for future deep and wide surveys such as Gaia and LSST. The fact that this catalogue goes approximately 3 mag fainter than the largest similar catalogue has already produced some interesting results in the study of halo structure and substructures.

More recently, Lovro has directed his work on a particular kind of pulsating red giants, the OGLE Small Amplitude Red Giants. This interesting and complex population is pervasive in the LMC, SMC and the Galactic Bulge. Furthermore, the subtypes show well constrained period-luminosity relations. Therefore these objects seem to be the perfect probe to explore the structure of the Milky Way and its satellite galaxies.



An example of LINEAR/SDSS synergy. Unfiltered LINEAR magnitudes (top) and SDSS colors (bottom). LINEAR provides better cadence for studying variable objects, while SDSS provides multi-band photometry that encodes valuable additional information.

DPAC meetings

Please note: Attendance at these meetings is restricted to members of the Gaia Coordination Units

Title ***Dates***	***Location***	***Convenor(s) /*** ***Local organiser(s)***
CU7: Variability Processing #16		
6 - 8 May 13	Aarhus, Denmark	L. Eyer / B. Tingley
Radiation Task Force #12		
7 - 8 May 13	Cambridge	F. van Leeuwen
GBOT #6		
13 - 14 May 13	Paris (Observatoire de Paris), France	M. Altmann / S. Bouquillon
CU4: Object Processing #15		
22 - 24 May 13	Florence, Italy	D. Pourbaix / A. Dell'Oro
CU6: Spectroscopic Processing #15		
29 - 31 May 13	Brussels	P. Sartoretti
CU9 kick-off meeting		
3 - 4 June 13	Barcelona	X. Luri / E. Masana
AGIS #19		
6 - 7 June 13	St. Petersburg	U. Lammers / S. Klioner
GBOG #13		
11 - 12 June 13	Observatoire de Paris	C. Soubiran / W. Thuillot
CU3: Core Processing #8		
26 - 28 June 13	ESTEC	U. Bastian

More information at http://www.rssd.esa.int/index.php?project=GAIA&page=Calendar_of_meetings