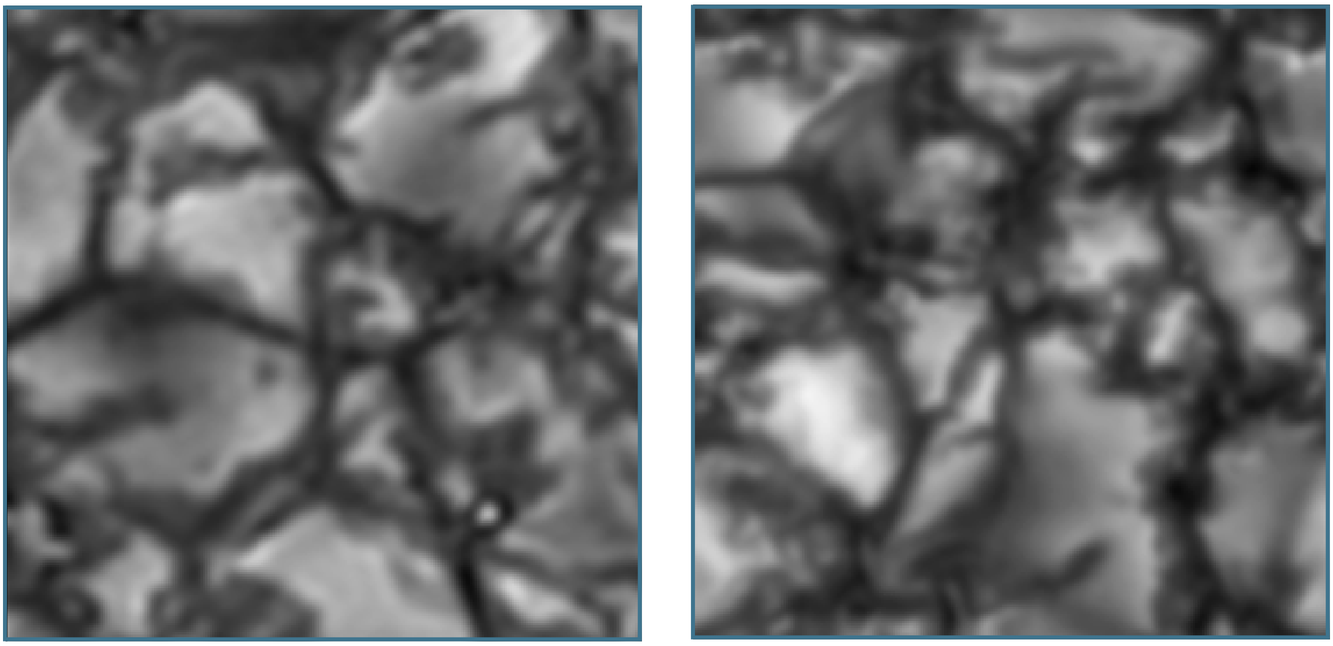
Gaia DPAC Newsletter 6

N° 6 - October 30, 2009

Accurate stellar atmosphere models for Gaia.

The inversion of Gaia spectroscopic data requires accurate modelling of stellar surfaces. The illustrations below show a comparison between the observed solar intensity and the synthetic image obtained from an hydrodynamical 3-D numerical model of the solar photosphere developed by Lionel Bigot in the Gaia team at the Observatoire de la Côte d'Azur.



Comparison between the observed solar emergent intensity made at the Solar Swedish Telescope (SST) (left panel above) and the synthetic equivalent (right panel). Each panel represents an area of 6000 × 6000 km.

- *(Left) G-band (430.5 nm) image obtained at the SST using adaptative optics and speckle reconstruction with resolution of 0.041"(30km). This image (unpublished) was kindly provided by J. Hirzberger. Data of the same observations may be found in Wiehr et al. (2004) and Hirzberger & Wiehr (2005).*
- *(Right) Synthetic image obtained by a 3D simulation (Bigot, unpublished) with a grid resolution of 512^2×384 (11.6 km horizontal). The synthetic image is smoothed by an Airy function that mimics the PSF of the SST.*

Editorial *by DPAC chair, François Mignard*

With the launch foreseen in less than three years, more and more of the Gaia subsystems are being delivered like the structure of the Service Module, the thermal tent that will surround the Payload Module. The deployable sunshield has been successfully deployed in open-air. All the flight model AF and BP CCDs have been delivered and show excellent noise and linearity performance, but required more calibration effort for offset instability. Finally the construction of the dedicated launchpad for Soyuz-ST near Kourou advances at great strides with a first launch scheduled in spring 2010.

For the DPAC the schedule is also tight, with our primary objective before launch to deliver a complete data processing chain able to transform raw observational material into intermediate and final science products. Despite all the efforts exercised in the development of the individual pieces of software, no one reasonably expects that the different modules will perform immediately well when integrated together. In this issue you will see how DPAC is planning the Integration Testing scheduled to start in mid-2010. This is a major milestone in the DPAC life and will keep many of us busy until the end of 2011, with the End-to-End testing. Also in this issue the presentation of the Photometric Science Alerts system set up in CU5 and that of the principles of the absolute calibration of the radial velocities contrived by CU6 astronomers.

Testing the DPAC integration: when the journey together begins *by Rocio Guerra (ESAC)*

Next year DPAC will face one of the major challenges in DPAC before Gaia's first transmission: the integration testing.

For the first time we will have the opportunity to demonstrate whether the whole machinery that makes up the data processing is properly integrated and is ready to start the journey in 2012 as the Gaia Science Ground Segment.

This challenge is at the same time a difficult task and a very exciting activity, in which all DPAC components must be committed from the initial phases.

Obviously, both the Coordination Units (CUs) and the Data Processing Centers (DPCs) will have performed (and will continue performing) extensive tests on their systems and resources before the integration tests, but this will be the first time that we will be able to evaluate how well the data will flow through all the chains and DPCs.

The objective of the integration testing is to demonstrate conformance with the requirements on the Gaia data processing. The main focus is on the interfaces and the data transfer through them: their functionality, robustness and performance. But the correctness of all the other of features (already tested in previous campaigns), will be also checked: systems' functionality, scientific assessment of the results, internal interfaces within the DPCs, etc.

Although the testing will start at the beginning of Cycle 9 – June 2010, it will continue for almost one year and a half. As one may imagine planning has already commenced. The master schedule and the test strategy are completely set.

Rather than a "big-bang" approach, by which all the systems are integrated and tested altogether, an incremental approach has been selected.

Following this criterion, a first step is planned, consisting on testing each interface between the DPCs in isolation. Due to the special topology of the data processing, a 'hub-and-spokes' model, these interfaces always connect the DPCE with the rest of DPCs (the Main Database is the hub receiving, storing and delivering the data).

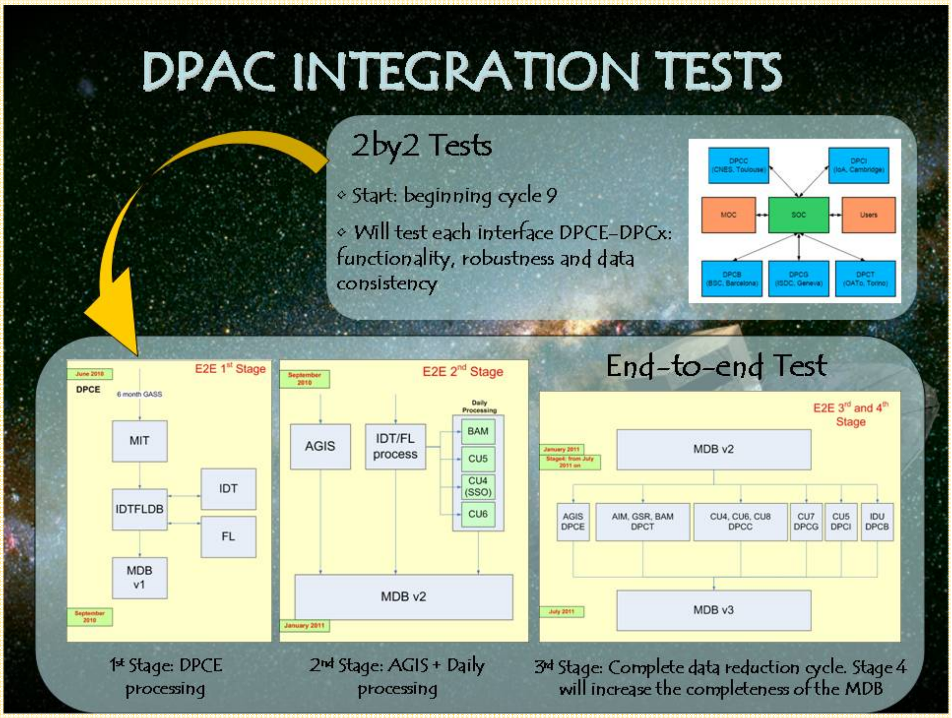
These tests, called '2by2', are intended to be the pre-step and aid of the final end-to-end test. With them, we expect to discover and solve most of the problems related to the external interfaces between the DPCs.

The final end-to-end test will demonstrate that the Gaia Science Ground Segment is ready for the early phases of the operations. The initial data reduction cycles will be reproduced, mimicking the real scenarios as much as possible.

As input data, CU2 will provide simulated telemetry stream during Cycle 8. This means that the database model must be completely defined by the end of the year, which implies a huge effort from all the CUs.

This simulated data – the only simulated data used - resembling the telemetry coming from the satellite will be ingested in the DPCE. From then on, the Gaia data processing will run as a whole: the Initial Data Treatment and First Look will generate intermediate data that will be stored and delivered to all the DPCs activating the different scientific chains that will progressively populate the Main Database.

Due to the number of distributed processes, this continuous data flow has been practically split into four different stages. A brief description of each one is given in the Figure below.



We know we will have to overcome many constraints and difficulties, some well known in advance, (e.g. problems derived of commencing testing so far ahead of launch) and others still unknown, (e.g. unpredictable delays, blocking failures, etc.).

The CUs and DPCs will continue improving the system even as we test it. But we believe that at the completion of these tests we will have confidence that DPAC can provide Gaia with a reliable and robust Science Ground Segment.

Focus on partners

Copenhagen University - The Niels Bohr Institute

by Jens Knude

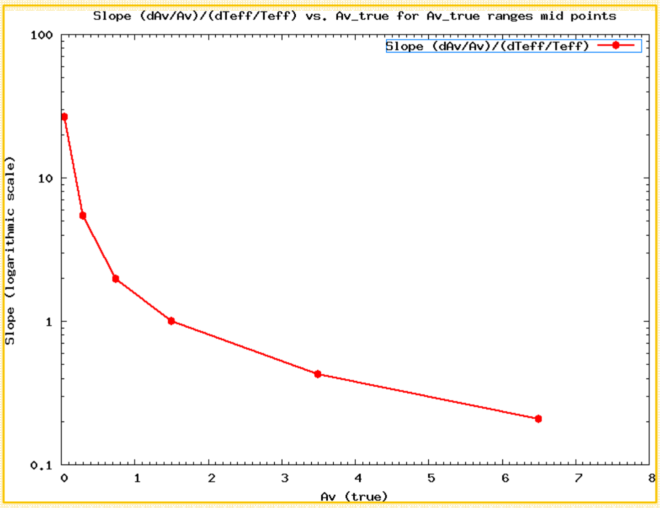
The Niels Bohr institute at the Copenhagen University is home of a number of research groups in physics, geophysics and astronomy. Our Gaia activities take place within the Astronomy group, in the Stars and Galaxies team (http://www.nbi.ku.dk/english/research/Astronomy/stars-and-galaxies/).

Under the guidance of Erik Høg the group has been deeply involved with Hipparcos and Tycho, continued in Gaia with the development of the original photometric system. Now the efforts are concentrated on the estimate of the galactic extinction with the spectrophotometric data. The Copenhagen team is part of the Interstellar Extinction (GWP-S-812) work package in CU8.

The main issue is the extinction law, i.e the dimming and reddening of stellar light as a function of direction and distance. All the photometric information provided by Gaia will be used, provided at good estimate of T_{eff} is available. We have assessed the sensitivity of the estimated A_V to the accuracy of T_{eff}, with main results shown in the figure below. This work is in progress and will continue with investigations of extinction within a given volume at varying distances.

Lately we have started addressing the question of the influence of the galactic extinction on the spectrophotometry of galaxies and quasars in Gaia data. Concurrently with our Gaia studies we consider how existing and future global photometric surveys may assist the use of the Gaia data, either in combination or separately.

Jens Knude from the Niels Bohr Institute and Hans Lindstrøm (CSC Denmark and The Niels Bohr Institute) are currently working on Gaia and since mid-October have been joined by Nadja Kaltcheva from the University of Wisconsin.



Sensitivity of the estimation of the interstellar extinction (A_V) to the stellar effective temperature (T_{eff}), expressed as d log A_V/d log T_{eff}. There is a strong amplification of the uncertainty in the weakly absorbing regions.

Geneva Observatory, University of Geneva, Switzerland

by L. Eyer / I. Lecoeur

The Geneva Observatory together with the Laboratory of Astrophysics of the Ecole Polytechnique Fédérale de Lausanne is one of the largest astronomical institutes in Switzerland with ~140 people. It comprises two entities: the Observatory and the ISDC Data Center for Astrophysics, dedicated to data processing for space missions.

The Geneva group builds on its rich experience in photometry, as well as its prior involvement in the Hipparcos mission, to lead the **Variability Processing and Analysis** Coordination Unit, **CU7**. In addition the ISDC hosts the associated Data Processing Center (**DPCG)**.

The CU7/DPCG main objectives are to analyze time series measurements in order to characterize and classify variable sources and to prepare the Gaia intermediate and final catalogue releases. For each variable source, we will provide information such as variability amplitude, period (if any), model-fitting parameters (e.g. Fourier series coefficients) and variability type (Cepheid, Eclipsing binary, etc).

One specific challenge is to exploit the various types of Gaia measurements, astrometric, photometric, spectro-photometric and those provided by the radial-velocity spectrometer, within the multi-epoch nature of the mission.

Our group of 16 people (8 FTEs plus PhD students, post-docs and scientific support) contributes to Gaia in several ways:

- Scientific research on asteroseismology, secular variability (i.e., stellar evolution detectable on a human time scale) and populations of variable stars;
- Coordination of about twenty European institutes;
- Software development;
- Support to the CU7 contributors for software integration and to the wider community through the production of the catalogue;
- Catalogue validation with the ground-based 1.2m Euler/Mercator telescopes at La Silla/La Palma.

Geneva also contributes to CU6 in the multiple transits analysis work package and to CU2 with models of variable objects implemented in the Universe Model.

http://www.unige.ch/sciences/astro/
http://www.isdc.unige.ch/Gaia

Radial Velocity Zero-Point for the Gaia RVS by G. Jasniewicz (GRAAL, Montpellier), F. Crifo (GEPI-MEUDON) - for DU640

The Gaia spectrometer (RVS) has no built-in calibration device and the RVS will rely on its own observations to carry out the wavelength calibration. Three categories of sources are envisioned for this purpose:

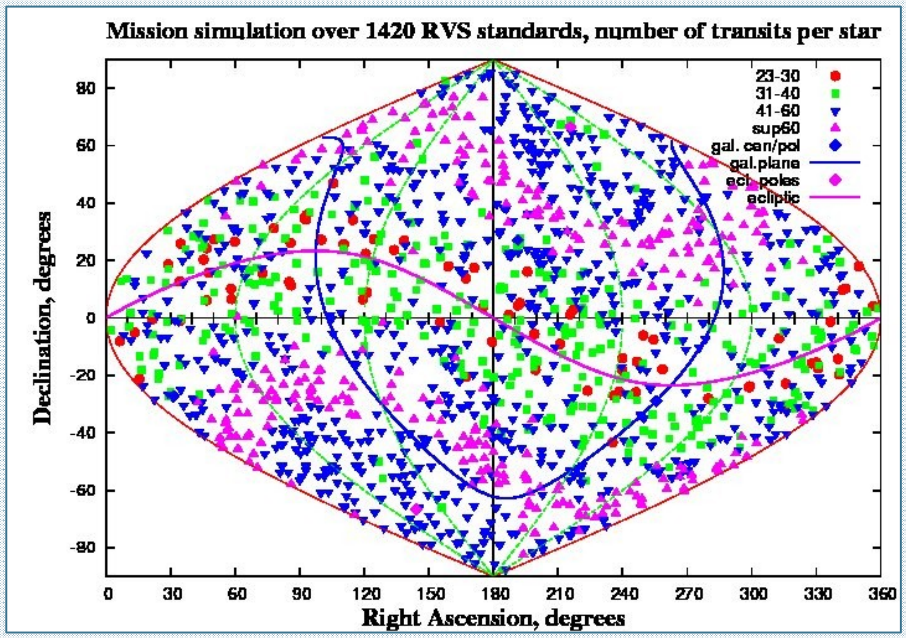
- A large sample of ~10^4 Gaia selected **RVS Reference stars**. There will be bright with stable radial velocities (RV) and will allow to iteratively derive the wavelength and the RVs in a consistent manner, but without a well defined origin. All RVs will be affected by a constant offset.
- The bright asteroids with perfectly known kinematical properties. But there are too few on the sky, and very unevenly distributed.
- A smaller sample of **RVS Standard stars** with stable RVs determined on the ground, prior or during the mission.

The last two categories will be used by the DU630 "RVS Calibration" to determine the remaining offset, referred to as the *zero-point corrections*.

A list of 1420 RVS-Standard stars has been established from existing RV catalogues, with criteria defined in the Gaia DU640 SRS document (see Jasniewicz et al. 2008). Ground-based observations of these stars and of bright asteroids are in progress in the framework of the GBOG Working Group.

How the stars have been selected, together with the observing programs in progress, will appear shortly (Crifo et al. 2010). A dedicated database has also been built for an easy use and check of the data obtained with different ground-based instruments.

We present here simulations of the Gaia RVS observations which have been carried out in order to verify, on a statistical point of view, the good temporal and spatial coverage of the sky for the subset of RVS-Standard stars. The efficiency of the iterative reduction process is obviously very dependent on this coverage. The simulated number of transits of our RVS-Standard stars in the Field of View (FoV) has been computed by P. Sartoretti, using the CU2 simulator and the nominal scanning law, with January 1st 2012 as start of the Gaia 5-year operational lifetime. On average there are 35-40 transits day^{-1} of RVS-Standards through the RVS FoV, the highest value being 81 and the lowest 10 transits day^{-1}. There are 17 days (about 1% of the operational lifetime of Gaia) with less than 20 transits day^{-1}, among which 2 consecutive days. 12 transits occur more than 6 hours after the previous one.



Coverage of the sky by the RVS-Standards, colour coded according to the total number of transits per star.

Upper magnitude V for asteroids	Number of asteroids through the FoV	Average number of transits per day	Number of days without transits	Longest period without transits
10	13	0.1 ± 0.5	1685 days	176 days
11	46	0.3 ± 0.8	1507 days	38 days
12	124	0.8 ± 0.3	1053 days	21 days
13	299	2.3 ± 2.1	484 days	10 days

Table : *Simulations of the daily number of transits of asteroids carried out by F. Mignard.*

Crifo, F., et al. 2010, SF2A-2009: Proceedings of the Annual meeting of the SF2A Eds.: M. Heydari-Malayeri, C. Reylé, R. Samadi.
Jasniewicz ,G., et al. 2008, DU640 "Radial Velocity Zero-Point" SRS, GAIA-C6-SP-UM2-GJ-001-4

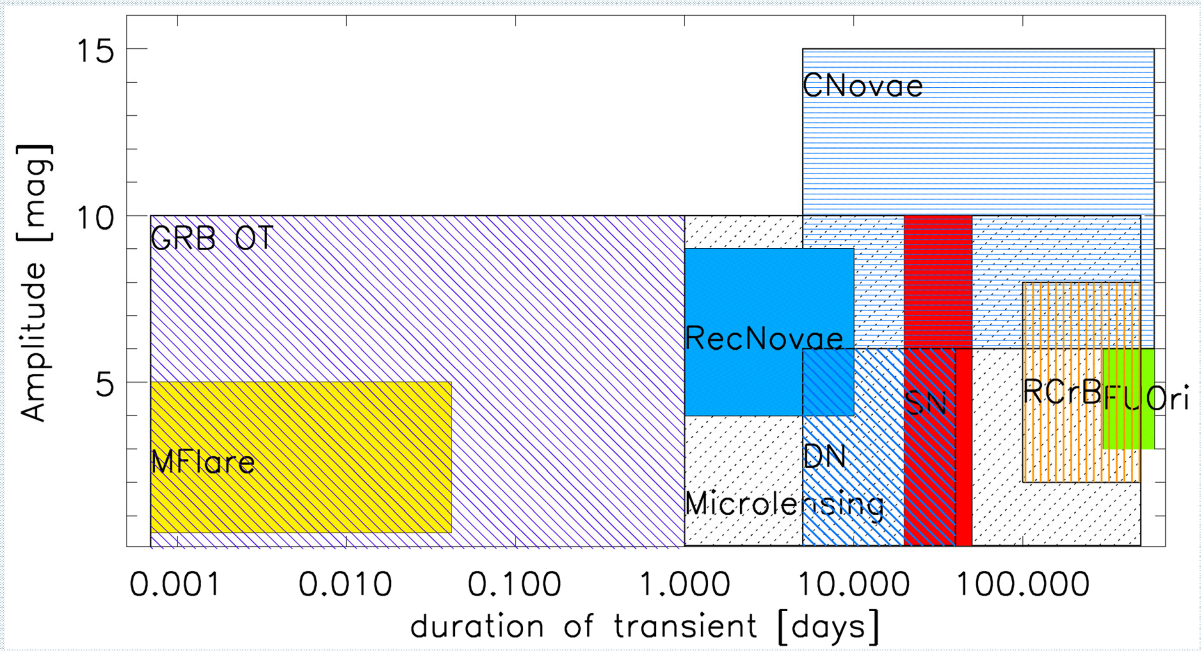
Photometric Science alerts *by Simon Hodgkin and Lukasz Wyrzykowski (Cambridge, UK)*

Gaia will observe the whole sky for 5 years, providing a unique resource for the discovery of large numbers of transient and anomalous events. Some of Gaia's strengths are the length of the mission, the high frequency of return visits to the same patch of sky, the high spatial resolution and sensitivity of the detectors, and that source measurement is not restricted by a pre-mission input catalogue (as was the case with Hipparcos).

The Gaia observing window for an arbitrary source is rather complex, but it's instructive to discuss the time-scales involved, and to compare these to potential transients (see the accompanying Figure). A typical point on the sky will be observed with between 30 and 200 distinct field of view transits over the entire mission. Each FOV crossing takes around about 40 seconds, with individual detections every 4.4 seconds for each AF CCD. The same field may be visited 106.5 minutes later by the second field of view, before disappearing for just over 4 hours, until the satellite spin brings the source into view again. The precession of the spin will take the source away from Gaia after several of these spin cycles for a period of time dependent on it's ecliptic latitude - it could be days or potentially months.

Obvious examples of photometric alerts include supernovae (all their different classes), novae and microlensing events. Less obvious examples may include the optical afterglows of Gamma-Ray Bursts, Fallback Supernovae, and other theoretical or unexpected phenomena. Simulations (e.g. Belokurov and Evans 2003) predict that Gaia will see more than 20,000 Supernovae, restricted to a local volume out to z~0.14. To maximise the scientific return from these observations, we need to analyse and release the Gaia alerts as rapidly as possible. In practice this will be limited by the time-scales for data downlink, initial data treatment, and transfer between the data processing centres.

The Gaia photometric science alerts Development Unit (DU17 within Coordination Unit 5) has been tasked with the development of software to enable the early detection of anomalous sources. In the first instance, this will be achieved by comparing the flux of a source in the most recent transit to it's accumulated Gaia photometry. New sources, or sources which have changed significantly since they were last seen, will be compared to template phenomena and given a preliminary classification (and a confidence in that classification). For interesting candidates, further comparisons to ground-based archives will add to the picture, and enable us to build a VOEvent compatible Gaia Alert for distribution to the world. Our software is still under development, and we value your input to ensure that the design maximises the scientific return from Gaia. Please contact the authors if you would like to be involved, or have a look at the Gaia Science Alert Working Group web pages at http://www.ast.cam.ac.uk/research/gsawg/



Simple cartoon to illustrate the expected amplitudes and timescales for some of the likely Gaia transient source detections. The various classes included in the plot are : M dwarf flare stars (Mflare: yellow), Recurrent Nova (RecNovae: blue), Classical Nova (Cnovae: blue horizontal stripes), Dwarf Nova (DN: blue diagonal stripes), SuperNova (SN: red), Microlenses (Microlensing: dot-dashed diagonal stripes), RCrB stars (RCrB: red vertical stripes), FU Orionis systems (FU Ori: green), Gamma-Ray Burst afterglows (GRB OT: blue diagonal stripes)

ELSA School on « the Techniques of Gaia » (28 September - 2 October), *by Stefan Jordan*

The meeting was held in Heidelberg with all 15 current ELSA fellows, 11 scientists in charge, 16 invited speakers, and half a dozen of other participants attending. It consisted of short conference-like presentations by the ELSA fellows and lectures by invited experts covering many different facets of 'The Technique of Gaia': the basics and history of astrometry, various aspects of calibration, data processing, hardware aspects, object classification, and orbit reconstruction.

An excursion to ESOC in Darmstadt illuminated details of the ground segment and flight dynamics and additional sessions dealt with the status of Gaia, gravitational lensing, cosmological parallaxes, predictions for the next solar cycle, and the future of space astrometry after Gaia.

For more information see http://www.astro.lu.se/ELSA/pages/N5info.html.

News & events: November in Nice!

The Observatoire de la Côte d'Azur (O.C.A.) and the Cassiopée Laboratory welcome the following Gaia meetings in NICE in Novembre 2009:

- **GBOT: Ground Based Optical Tracking on November 16 - 2009.**
- **GBOG: Ground-Based Observations for Gaia on November 17 & 18 - 2009**
- **CU8: Astrophysical parameters on November 17 & 18 - 2009**
- **GREAT: Gaia Research for European Astronomy Training on November 19 & 20 - 2009**
- **CU6: Spectroscopic Processing November 23, 24 & 25 - 2009**

Calendar of next DPAC related meetings

Date	Place	Who	Type	Resp.
09-11/11	Geneva	CU7	Plenary	Eyer
12-13/11	Dresden	CU4	Plenary	Pourbaix / Klioner
16/11	Nice		GBOT	Altmann / Rousset
17-18/11	Nice	CU8	Plenary	Bailer-Jones / Thévenin
17-18/11	Nice		GBOG	Soubiran / Bendjoya
19-20/11	Nice		GREAT	Walton / Mignard
23-25/11	Nice	CU6	Plenary	Katz / Thévenin
26-27/11	ESAC		AGIS#12	Lammers
01-03/12	Barcelona	CU5	Plenary	van Leeuwen / Balaguer
11/12	London	Steering com.	MLA SC#05	Castelli / Prusti
17-18/12	Paris	CU3	REMAT#06	Klioner / Le Poncin-Lafitte

More information on calendar of Gaia : http://www.rssd.esa.int/index.php?project=Gaia&page=Calendar_of_meetings

This newsletter is published by DPAC Chair
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