Gaia DPAC newsletter

N° 2 — October 16, 2008

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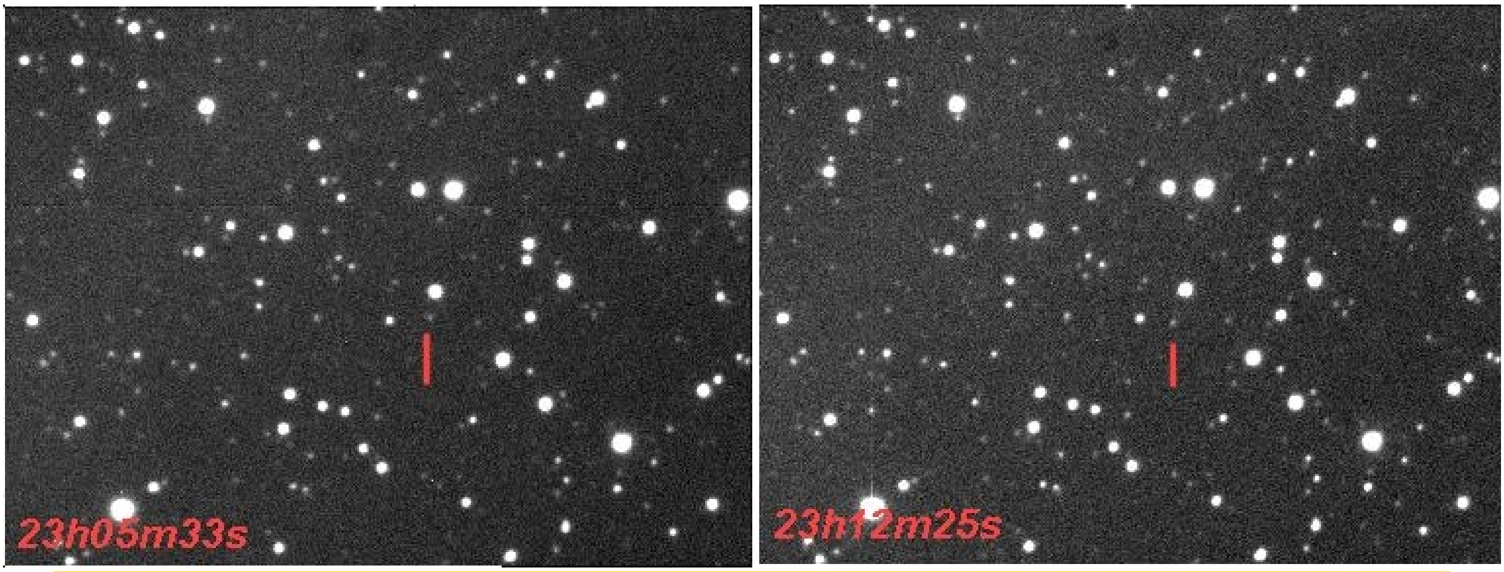


Pictures of WMAP against background stars taken on 13 July 2008 at the Pic du Midi by F. Colas and F. Taris. The magnitude of the spacecraft is about 18.5 mag and the total displacement over the 7 mn is 4.3 arcsec. The subsequent astrometric reduction by F. Taris and S. Bouquillon, from the SYRTE at the Observatory of Paris, with the UCAC2 catalogue for the reference stars has an accuracy of about 40 mas in both direction. The goal for the observation of Gaia with the first version of the Gaia astrometric catalogue is 10 mas per observation.

Editorial *by DPAC chair, François Mignard*

It has been almost six months since the release of the first issue of the DPAC NewsLetter instead of the three month interval we initially planned. But with the return of Sophie (the editor of the letter) from maternity leave we hope to keep with our promise to issue the NewsLetter every three months.

Several key events happened over the last six months with in particular the signature between ESA and Astrium in August 2008 of the contract for the Phase C/D meeting the SPC budget for Gaia. The 17 SiC segments of the torus bench are under production and will be brazed together into a single piece of 3.5m in diameter. The CCDs production has been temporarily stopped due to the detection of bonding problems which are under investigation. All the mirrors have their blanks completed and are being polished or coated. The RVS has gone through a major redesign by Astrium to achieve better performances.

For the DPAC activities, progress is seen in every side of the development with a huge variety and volume of simulated data produced by CU2. The impact of the radiation damage and how to deal with it in the data modelling remains the major uncertainty at this level although joint work between the project, the DPAC and Astrium shows real advances in the mitigation, but no perfect solution.

With a launch scheduled in just above three years the time ahead is short before we start the end-to-end testing of the whole system, meaning that there is no time to waste and the objectives set for each cycle must be met.

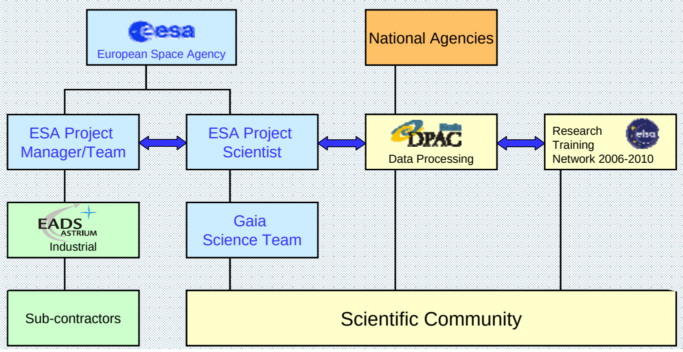
The Gaia Science Team and the ESA Project Scientist *by Timo Prusti*

2007 was a year of milestones for Gaia. The spacecraft passed the Preliminary Design Review (PDR), DPAC was formally approved, new Project Scientist took up duty, and the new Gaia Science Team (GST) was selected.

Every ESA mission has a Science Team selected from the community with the main task of advising the various project elements in all scientific matters.

The GST is consulted for advise as needed and additionally meets three to four times a year to monitor progress and take stock of long term activities. While the various elements like EADS Astrium building the satellite and DPAC taking care of the data processing have a role to implement their part of the mission, the GST has a purely advisory role to fulfil. This is the case for the ESA Project Scientist as well. The main difference is that the GST has the broader scientific expertise while the Project Scientist has the responsibility on an everyday basis. One can also say that the role of the GST and Project Scientist is to bridge an interface: GST with an emphasis toward the general astronomical community and the Project Scientist with an additional duty to ensure the information flow between ESA/Industry and DPAC. It is not easy to list all the topics needing to be tackled under the advisory mandate and one may better state the requirement on GST and Project Scientist activities that they should work toward maximising the overall scientific return of the mission.

The GST members were selected to ensure a broad coverage of expertise. The astrometry members are S. Klioner (Dresden) and L. Lindegren (Lund). The photometry specialists are C. Aerts (Leuven) and C. Jordi (Barcelona). The RVS scientists are E. Grebel (Heidelberg) and S. Randich (Arcetri). The data processing representative is N. Walton (Cambridge). In addition the DPACE chair, F. Mignard, and the ESA Project Scientist, T. Prusti, are members of the GST.



Information from DPAC Executive (DPACE) *by François Mignard*

◊ Among the top documents ruling the activities of the DPAC, one must note the advanced draft of the ICD with ESA. This document, jointly prepared by the Gaia Project and the DPAC, defines in detail the list of items required by DPAC and to be provided by the ESA Gaia Project. This is primarily a list of items required by DPAC to successfully design, implement, validate and operate the Gaia data reduction, with delivery dates for each entry. The items covered range from the basic spacecraft information on the optical configuration, detectors to the on-board attitude or the event timing.

◊ The creation of the DPAC project office has significantly progressed with at least three countries providing funding and an agreement on the positions to be filled, namely that of Project Coordinator (PC), Interface Engineer (IF) and Project Scheduler (PS). Calls for applicants have been issued in Germany and Spain and an applicant for PC has been also proposed by Italy. In total 12 applications were validated, out of which 7 applications were selected for an interview. The hiring of the PC and PS are nearly completed and the PO should be in place by the start of 2009 at ESAC.

◊ The DPACE has set up a Risk Register under MANTIS track tool. It compiles the list of risks identified by each CU and the DPACE itself, defines the severity and likeliness of the risk and the actions taken to avoid or limit the consequences when this makes sense. The overall principles were laid out in a Risk Management Plan prepared by R. Drimmel and T. Lock and at the moment more than a hundred risks are documented.

◊ To achieve the Gaia data analysis the DPAC needs reference data to initiate the attitude determination or in photometry and spectroscopy to fix the magnitude system or the wavelength zero-point of the spectra. These auxiliary data must be obtained in advance from ground-based observations and a dedicated working group (the GBOG: Ground Based Observations for Gaia) chaired by C. Soubiran from Bordeaux coordinates the activities. More than 30 programs are underway including a recently accepted ESO large program in spectro-photometry led by E. Pancino from Bologna.

http://www.rssd.esa.int/wikiSI/index.php?title=GBOG *(DPAC restricted)*

GAIA or Gaia?

... Gaia is the Greek Goddess of the Earth

Originally in response to ESA (~1995) this was :

GAIA: Global Astrometric Interferometer for Astrophysics

However in 2000 Concept and Technology Study report, the mission is no longer based on interferometer but has retained the name GAIA (without explicit meaning).

Now this is simply **Gaia** : a proper name, not an acronym *(should not be written GAIA!)*

Consortium main figures* *based on data from 'My Portal ESA lists' on September 20th, 2008.*

Active Members per agencies/ CU *(including multiple participations)*

Note: CU0 is the administrative unit of DPAC

Agency\CU	CU0	CU1	CU2	CU3	CU4	CU5	CU6	CU7	CU8	Total
Austria								2		2
Belgium		1			15		12	13	7	48
Brazil			1	1	1					3
Canada			2							2
Czech Republic			1					4		5
Denmark						1		1	2	4
ESA		18		13						31
Estonia									1	1
Finland					4					4
France	2	8	29	11	30	2	31	5	16	134
Germany		1	4	20	2	1	3		4	35
Greece			7		2				8	17
Hungary								1		1
Italy	1	3	13	22	7	20		11	8	85
Lithuania									3	3
Netherlands			1			6				7
Portugal		2	3	1				4		10
Russian Federation					1					1
Slovenia							2			2
Spain		5	13	12		10		1	4	45
Sweden		1		3					7	11
Switzerland		2	1		2		3	15		23
United Kingdom		4	3	3		29	10	1		50
United States							2		1	3
Total	3	45	78	86	64	69	63	58	61	527

This table of Efforts shows a total of **527** participants to DPAC, although there are only **386** individuals.

This is due to multiple CU membership:

- ☞ 276 persons contribute to only 1 CU,
- ☞ 89 persons contribute to 2 CUs,
- ☞ 14 persons contribute to 3 CUs,
- ☞ 4 persons contribute to 4 CUs,
- ☞ 3 persons contribute to 5 CUs.

Universidad de Barcelona *By Jordi Torra*

The Department of Astronomy of the University of Barcelona hosts a Gaia group of around 20 people funded primarily by the Spanish Ministerio de Ciencia e Innovación. 5 senior scientists, 6 PhD students, 7 postdocs and 3 engineers are involved in CU2, CU3 and CU5. The group also includes an ELSA student and a Consolider student in collaboration with the Barcelona Supercomputing Center.

Xavier Luri is manager of CU2 "Data Simulations" with the development of the GASS and GOG simulators. GASS is designed to simulate the telemetry stream of Gaia according to the design specifications, using a detailed sky and instrument model while GOG is a tool to directly produce elaborated data of the Main database -MDB- bypassing the intermediate processing stages.

Jordi Torra is deputy-manager of CU3 "Core Processing" in charge of designing and developing the first data processing stage of DPAC (IDT), including telemetry decoding and calculation of intermediate data for AGIS and other CUs. We also implement IDU, which will re-process periodically the accumulated raw data of the entire mission and the radiation damage effects. Also IDV, a systematic and exhaustive validation tool for IDT and IDU has been developed.

Our participation in CU5 "Photometric Processing" includes the development of models for the internal calibration for G and BP/RP and the selection of internal reference sources for such calibration, as well as collaborating on the ground-based observations for absolute fluxes determination in the DU13.

http://gaia.am.ub.es/

Mullard Space Science Laboratory *By Mark Cropper*

MSSL is the oldest and largest university space science group in the UK, with some 15 instruments currently operational on 10 different missions from all of the major space agencies.

MSSL has contributed in many areas of the *Gaia* programme, including:

- ◊ the definition of the mission requirements,
- ◊ the exploration of technical solutions in the CCD detection chains and spectrometer, as a subcontractor for the CCD and detection chain characterisation,
- ◊ in several consultative capacities (reviews, committees and the *Gaia* Science Team),
- ◊ and in the development of the *Gaia* data handling within DPAC.

Our main role here is in the CU6 "Spectroscopic Processing", and we're responsible for the initial processing and calibration of the spectra and, as the mission progresses, for their combination to provide the final end-of-mission radial velocities.

Future projects beside *Gaia* include *JWST, ExoMars, Solar Orbiter, Herschel* and *AstroSat* and we are involved in several of ESA's Cosmic Vision programmes. MSSL is a department within University College London, a major London university but we are on a separate site in the beautiful Surrey countryside. We have research groups in astrophysics, space plasma physics, Solar physics and Earth climate physics, all of whom work in close collaboration with the engineering and instrumentation groups. Given that there are around 50 people on the site, this high level of interaction is guaranteed!

http://www.mssl.ucl.ac.uk/

***Note:** All data in this section are available at (DPAC restricted) http://gaia.esac.esa.int/dpacsvn/DPAC/docs/newsletter/NL_02/material*

Science and technical issues

DPAC Development cycles *by François Mignard*

The Gaia Data Processing is a huge task involving many kinds of software developments, testing and implementation together with voluminous data exchange between the Data Processing Centres (DPC). This cannot be expected to work in one shot with an operational version in place without intermediate steps. To fill this needs the DPAC has adopted development cycles as a fundamental element of its SoftWare development strategy. During each development cycle, requirements are specified, code developed, delivered and tested. During this phase each cycle covers a period of 6 months with objectives set in advance and simulated data produced accordingly by CU2. Following a proposal from U. Lammers (DPAC/ESAC) the cycles are named after the ten highest terrestrial peaks in ascending order. The current cycle *Cho-Oyou* (the sixth highest peak) will end on November 2008 with the start of *Makalu*. A similar strategy will be followed for the actual processing and the production of the different versions of the solution during satellite operation.

Additional information on : http://www.rssd.esa.int/wikiSI/index.php?instance=Gaia *(DPAC restricted)*

Gaia and periodic variable stars *by Laurent Eyer and Nami Mowlavi*

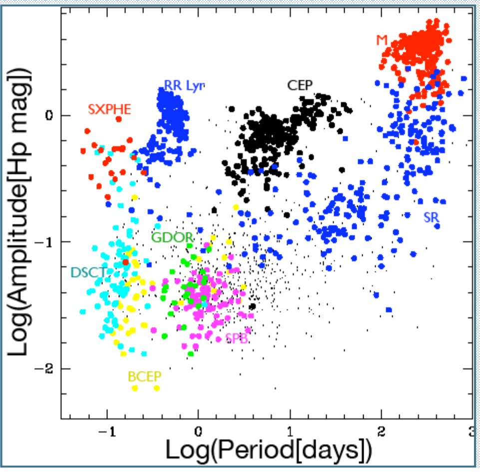
Each celestial object observable with Gaia with a magnitude between V=6 and 20 will be recorded on average 80 times during the mission (the actual number ranging between about 40 and 250 depending on the position in the sky). The resulting time series collected in the focal plane will provide unique opportunities for variability analysis. Among the billion objects that Gaia will see, about 10% may be detected as variable, with about 25 million expected to be seen as periodic variables. The variability analysis of those objects will benefit from the near-simultaneous availability of the photometric data in the G-band, of the spectro-photometric data in the red (RP) and blue (BP) parts of the visible spectrum, and, for half of the photometric measurements, of the data collected by the Radial Velocity Spectrometer. Moreover, the photometric precision reached in the G-band will allow the study of variability down to the milli-magnitude level for objects with V=12-13 (down to 20 mmag at V=20). The RP and BP bands, on the other hand, are three times less accurate due to smaller integration times. The effort of analysing the variability in the Gaia time series is led by Geneva within Coordination Unit 7.

The Gaia scanning law produces irregular time samplings with gaps of several weeks between clustered observations. This irregularity is actually an advantage for the analysis of periodic light curves for it reduces aliasing introduced in the signal. The expected efficiency of period recovery from the Gaia time series mostly depends on the ecliptic latitude of the object. A study completed by Eyer and Mignard (2005) shows that the probability to recover a period can exceed 95% for ecliptic latitudes between 40 and 70 degrees, even for S/N ratios as low as ~1.3.

Periodic variables, whether stable on long time scales, like classical pulsating stars or eclipsing binaries, or on shorter time scales like the rotation-modulated variables, will be of particular interest with Gaia. In the colour-luminosity Hertzsprung-Russell (HR) diagram, the regions populated by different types of variable stars will be delineated with unprecedented accuracy, and the instability regions clearly defined. This will enable not only a better identification of the physical processes at the origin of the periodic variability of a given object, thereby allowing its classification, but also the analysis of a given population of variable stars as a whole, constraining for example their dependency on metallicity.

Finally, shorter time-scales may be investigated with the data collected by Gaia. The analysis of the individual photometry collected by each of the nine CCDs over 4.4 second time intervals will have the potential of detecting short-period variables such as pulsating compact objects (white dwarfs and sub-dwarfs), beta-Cephei stars, delta Scuti stars, roAp stars, as well as eclipsing binaries of compact stars.

In summary, Gaia will provide an unprecedented representation of variable stars in the HR diagram, a classification of the periodic objects into their variability classes and a deeper insight into the physical processes at the origin of the variability. Diagrams of variable stars such as the HR diagram or the period-amplitude diagram presented here will be extended to contain millions of objects with variability amplitudes and periods down to the milli-magnitude and few tens of seconds level, respectively .



Distribution of the pulsating variable stars detected by Hipparcos in a period-amplitude diagram. The types of variable stars represented in the diagram are Miras (M), Semi-Regulars (SR), Cepheids (CEP), Slowly Pulsating B stars (SPB), gamma Doradus stars (GDOR), RR Lyrae stars (RR Lyr), SX Phoenicis stars (SXPHE), delta Scuti stars (DSCT) and beta Cephei stars (BCEP). From Eyer & Mowlavi (2007).

Ref.: L. Eyer & F. Mignard 2005, MNRAS 361, 1136 L. Eyer & N. Mowlavi 2007, in Proc. "Helioseismology, Asteroseismology and MHD Connections", eds. L. Gizon & M. Roth (astroph 0712.3797).

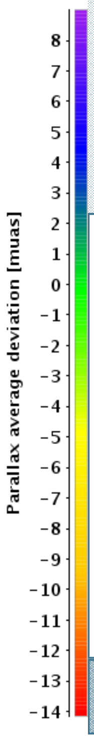
Science and technical issues

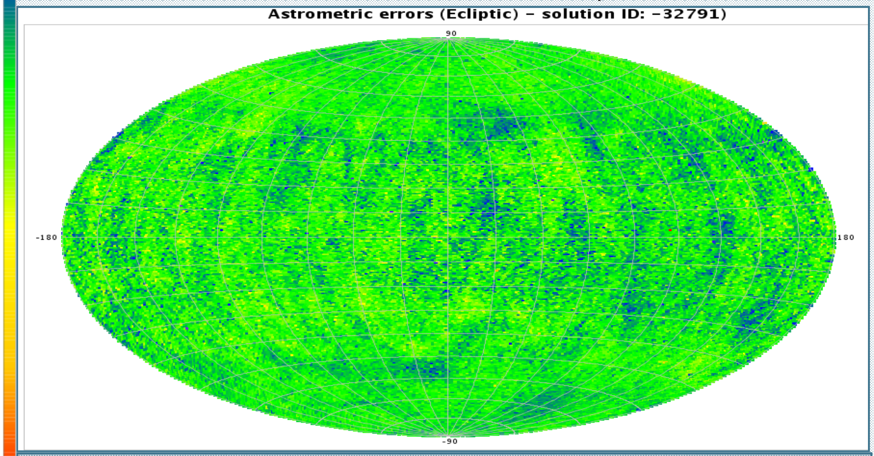
Developing Gaia's astrometric solution seeker *by Uwe Lammers*

The Astrometric Global Iterative Solution (AGIS) is the mathematical framework chosen to generate Gaia's astrometric mission products from all Astrometric Fields measurements made in the operational phase. A pure Java implementation of AGIS is being developed under CU3 WP M-320 at ESAC and Lund Observatory with contributions from ARI (Heidelberg) and Lohrmann Observatory (Dresden).

Large-scale validation tests using simulated data sets provided by CU2 are being executed on dedicated processing hardware at ESAC.

Since the first working version of AGIS, these tests continue to produce good results and an example is given in the figure below. It shows an all-sky Hammer-Aitoff projection in ecliptic coordinates of the parallax errors (in the sense AGIS-computed minus true value averaged over all sources (~50) in a given pixel) resulting from a recent AGIS processing cycle using a dataset with 2 million single, astrometrically well-behaved stars. The cycle started from very conservative initial errors in the unknown source, attitude, and calibration parameters (50 mas Gaussian errors plus a systematic variation with an amplitude of a few 10 mas). The cycle was considered converged after 24 iterations when the width of the parallax update distribution became less than 1 muas. With final errors of less than 15 muas the convergence process has reduced the initial errors by more than three orders of magnitude. The end result is close to the goal of achieving residual astrometric errors that are consistent with the observation noise and with remaining systematic errors much smaller than the random errors.





All-sky Hammer-Aitoff projection in ecliptic coordinates of average parallax errors from AGIS cycle 1175 .

The error pattern seen in the map "echoes" the Nominal Scanning Law in the sense that the solution is most rigid in the polar regions where the number of observations is largest. In the area between ecliptic latitudes -45 and +45 degrees the errors are higher because of fewer observations contributing to the solution and a less favourable scanning geometry. Improved solution methods are being studied which may eventually bring down the residual systematic errors by another significant factor.

In addition to the scientific validation aspects the tests are also used to continuously monitor and improve the FLOP count estimates needed to size the operational AGIS hardware. Given time runs of one iteration of 1h/10^6 stars on the current ESAC cluster the FLOP count estimates remain fairly stable at about 1.4 x 10^{20} for the creation of the final catalogue and 2.2 x 10^{19} for the final processing cycle with the full 5 years of data. Encouraged by the good results and steady development progress the AGIS team remains highly motivated and dedicated to create the best possible astrometric core solution for Gaia.

WMAP posing as test object for Gaia's Ground Based Optical Tracking Project *by Martin Altmann*

The unprecedented precision of Gaia's astrometric measurements requires very precise knowledge of the satellite position and motion itself.

To precisely measure the parallaxes of solar-system bodies and to correctly take the aberration of light into account, we need to know the precise 3D-position of Gaia to 150 m, and its velocity to 2.5 mm/s. This is beyond what the single tracking station available to the mission can deliver.

To meet this very demanding requirement, several approaches are currently being investigated by the DPAC, one of them being to monitor Gaia from the ground, and to measure its position in the sky and its tangential velocity to a precision of about 10 mas and 10 mas/day. To achieve this, a world-wide observing campaign needs to be established; several telescopes around the world will deliver at least one measurement per day. Currently the method is being tested using another satellite located in the L2 region, where Gaia will be placed: WMAP. This spacecraft is of similar structure and orientation to the Earth as Gaia, just smaller; hence we expect WMAP's brightness not to be to dissimilar to the currently unknown brightness of Gaia. The results of the first observations of WMAP by R. Smart, S. Bouquillon and A. Andrei using the 2.2 m telescope + WFI at ESO La Silla and by F. Colas and F. Taris with the 1.06 m telescope on Pic du Midi (shown on cover) are very encouraging in terms of reaching our precision goals.

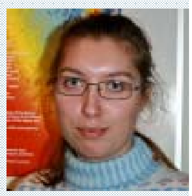
Also check Picture on the front page.

Focus on ELSA programme

Maya Belcheva is a PhD student at the University of Athens. Her PhD is supported by the EU RTN project `ELSA' and deals with "Spatial distribution of stellar populations for galaxies resolved in stars by Gaia". Maya's work is closely related to CU2-DU3, which is responsible for the Gaia Universe model.

Gaia will resolve nearby galaxies in stars. The main goal of this project is to obtain the spatial distribution of different stellar components in these galaxies. The Magellanic Clouds, being the nearest neighbours of our Galaxy, are the most important targets with a large number of observed stars. In order to obtain their spatial distribution our team uses already existing catalogues, which are homogeneous, have a good coverage of the galaxies, and are deep enough. Such are "The Magellanic Clouds Photometric Survey: SMC", "UBVR CCD survey of the Magellanic Clouds", "SuperCosmos Sky Survey", etc. We need to obtain the stellar density distribution and produce a model of the spatial distribution of the Magellanic Clouds. Since the ground-based catalogues have a different spatial resolution that Gaia's, the next step will be to adapt the results that it matches Gaia's spatial resolution. The latter is expected to be similar to that of the Hubble Space Telescope.

The final step will aim to include these spatial distribution models of nearby galaxies in the Gaia Universe Model. The Universe Model is a set of algorithms used by the data generators of the Gaia simulators - GASS, GIBIS and GOG - to generate simulated data in the framework of Gaia data reduction preparation.



It generates astronomical objects and their observable characteristics, like position, brightness, variability or spectrum.

News from GREAT *(Gaia Research for European Astronomy Training)*

The European and wider astronomy community, especially those who will benefit from the use of the astrometric, photometric and spectroscopic data from the Gaia satellite, have been invited - jointly by ESA, GST and DPAC - to express their interest into building a GREAT European Science Foundation (ESF) Research Network Programme (RNP).

We have received 57 proposals. Most of them issued from Institutes accounting for several people, although few have been also sent by individuals.

The proposal will be submitted to ESF by the end of October 2008.

More information on GREAT website at http://www.ast.cam.ac.uk/GREAT/index.html

Calendar of DPAC related meetings

Date	Place	Who	Type	Resp.
20-21/10	Bologna		GBOG	Soubiran / Pancino
22-24/10	Besançon	CU2		Luri / Robin / Reylé
12-14/11	Prague	CU7	Plenary	Eyer / Koubsky
13-14/11	Besançon	CU3	REMAT-04	Klioner / Fienga
20-21/11	Bordeaux	CU4	Plenary	Pourbaix / Ducourant
24-26/11	Brussels	CU8	Plenary	Bailer-Jones / Fremat
27-28/11	ESTEC	GST- 25		Prusti
02-04/12	Montpellier	CU6	Plenary	Katz / Jasniewicz
04-05/12	Dresden	CU3	AGIS#10	Klioner

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
To publish news or articles please contact: sophie.rousset@oca.eu