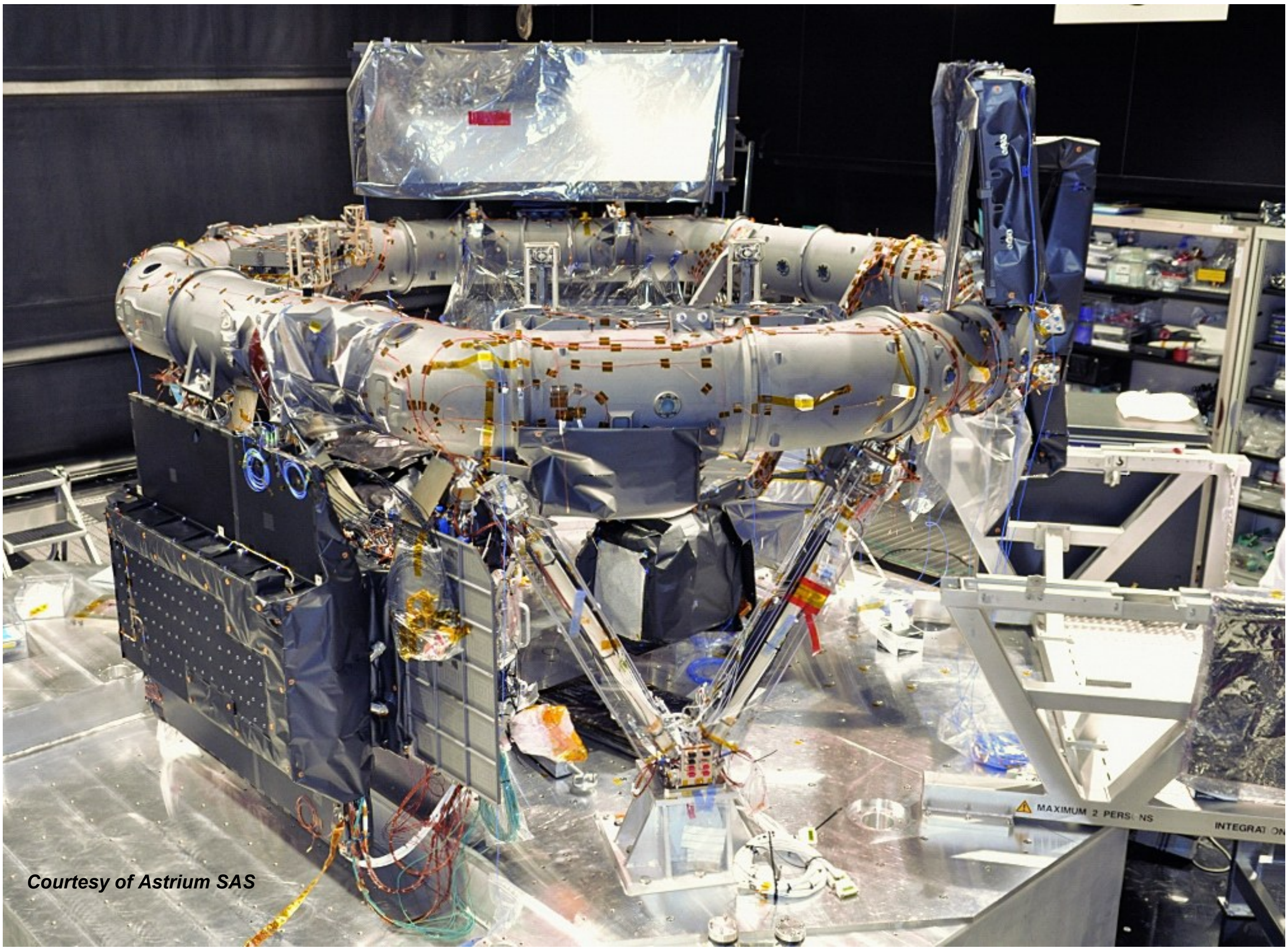
Newsletter 18

N° 18 - October 26, 2012



Courtesy of Astrium SAS

Gaia Payload Module fully assembled (except for external insulation *MLI*) ready to start the final environmental tests campaign.

Editorial *by DPAC chair, Anthony Brown*

The impressive picture above shows the Gaia payload module during integration.

The payload is currently in Liege, Belgium, awaiting the thermal balance/thermal vacuum tests that will be conducted in December. During the summer there was a bit of a scare for the RVS instrument, concerning the quality of the transmission filter. However, this was resolved quickly and satisfactorily as you can read in the 'DPAC news' section.

The launch of Gaia is now fast approaching, a launch slot for end 2013 has been requested, and since the first operations rehearsal everyone is very much aware of the large amount of work still to do to get DPAC fully ready for launch. The preparations for the second operations rehearsal in December are well under way. During this rehearsal the circumstances during commissioning will be simulated which should help to crystalize the DPAC plans for commissioning. In parallel the calibration team at SOC is starting to work out in detail the various calibration procedures that will be uploaded to the spacecraft during commissioning. It's all starting to feel very real!

Finally, as you can see from the header of the Editorial, DPACE has a new chair. I have started on October 1st and I would like to also use this platform to thank François Mignard and Ronald Drimmel for the excellent work they have done over the past six years as chair and deputy chair of DPACE.

DPAC News

During the complicated alignment of the telescopes and the radial velocity spectrometer optical components, problems were found with the wavefront quality. These were eventually traced to faulty software in the measuring devices, but in the process a closer examination of the RVS components revealed a real wavefront quality problem at the RVS filter level. A very subtle ring-like structure on the bandpass filter plate caused the degradation of the wavefront errors to a level which would lead to a significant loss of spectral resolution over significant parts of the RVS focal plane.

The problem was traced to the details of the filter coating deposition process. The ESA project team and Astrium decided to request Barr to manufacture a new filter to replace the one already integrated into RVS. This was a risky operation as it was not guaranteed that the dismounting, fixing, and re-integration of RVS on the payload module could be done before the PLM TB/TV tests, and more importantly, before the PLM and SVM integration.

Remounting RVS after PLM-SVM integration would have had serious schedule implications. Fortunately Barr was able to quickly manufacture a new filter after changing their coating deposition process. The new filter turned out to have wavefront errors within specification meaning that the RVS spectral resolution was also in specification again. The developments went so fast in fact that the RVS has been dismounted and reintegrated onto the PLM during the time that the PLM was being prepared for the TB/TV tests in Liege!

There is a slight price to pay in that the filter response has shifted a few nm to the blue, implying a slight loss of astrophysical information towards the red wavelength limit of the RVS bandpass. Nevertheless we can be very happy about this successful collaboration of ESA, Astrium, and Barr to fix the RVS.

Words of Gaia: *Lagrangian point L2*

The problem of the motion in space of three gravitating bodies puzzled several mathematicians, starting with Newton itself. It was one of the brightest mathematicians of all times, Joseph-Louis Lagrange (1736 - 1813), who was able to successfully attack this problem among his many other noted contributions in calculus, number theory, algebraic equations, mechanics and astronomy.

Lagrange, in his Prize winning paper *“Essai sur le Problème des Trois Corps” (1772)*, discovered very general, stationary or not, periodic solutions in the relative motion of three gravitationally interacting masses. In one solution, the three bodies could stay at the vertices of a rotating equilateral triangle, maintaining constant distances between the bodies.

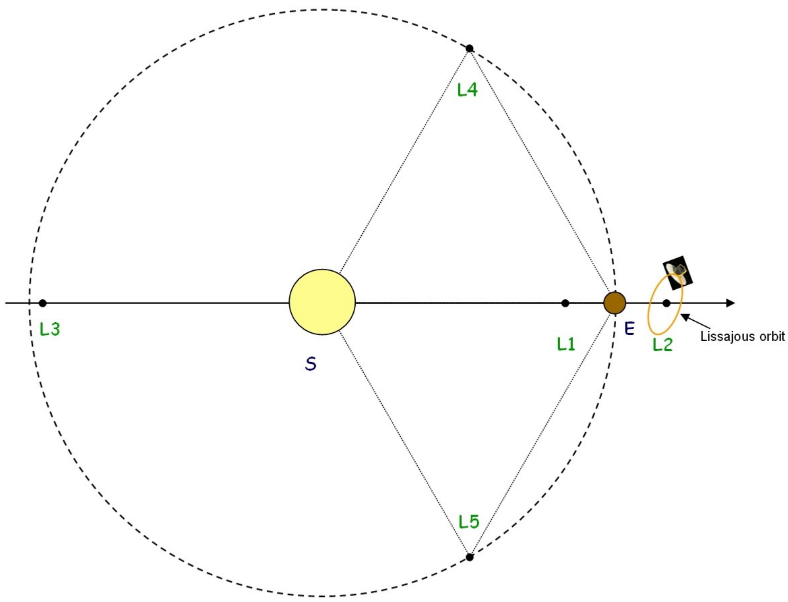
In a restricted version of this problem, when one mass is very small compared to the other two, several properties of the Lagrange's solution can be easily illustrated in a frame corotating with the two main bodies when they move on circular orbits about their centre of mass. The relevant five equilibrium points are now universally referred to as the 'Lagrangian Points', conventionally designated by L1, L2, ..., L5.

While L1, L2 and L3 are aligned with the two masses, L4 and L5 form an equilateral triangle (see figure).

Since L4 and L5 are stable for test bodies, small bodies can stay in their immediate vicinity. This is the case – for example – for the several “Trojan” asteroids leading or trailing Jupiter in its orbit by about 60 degrees.

Conversely, L2 is unstable but has been chosen as a sweet spot for several space missions (such as WMAP, Planck, Herschel,…) including Gaia, primarily for its very stable environment, despite the large distance to the Earth (about 0.01 au) compared to a geosynchronous orbit.

To stay there, a probe like Gaia applies frequent corrections to its trajectory, typically once every month. In return, it will remain in the stable thermal environment required for its operations and won't be disturbed by the Earth glow.



Qualitative positions of the Lagrangian points for the Sun-Earth system (Figure not to scale).

The Laboratoire d'Astrophysique de Bordeaux *by C. Soubiran*

The 'Laboratoire d'Astrophysique de Bordeaux (LAB, http://www.obs.u-bordeaux1.fr/)', previously Bordeaux Observatory, was founded in 1878 by Georges Rayet. Among its contributions in optical astrometry, it provided thousands of stellar positions from its Meridian Circle to the Hipparcos input catalogue.

Research fields at LAB (~70 people) cover reference systems and AGN, stellar kinematics and abundances, dynamics of disks, star formation, astrochemistry, planetary science. The LAB contributes, technically and/or scientifically, to Herschel, ALMA, EVN (European VLBI Network) and Gaia.

Our involvement in Gaia started in 1999 within the working group on classification and stellar parametrization. The Gaia Team now has 7 permanent researchers, 2 post-docs, 1 engineer and 1 PhD student providing about 3 FTE in the following activities :

- Compilation of auxiliary data for the calibration of the RVS data products. A major achievement is the publication end 2012 of the catalogue of RV standard stars for Gaia which required ~80 observing nights over 6 years.
- Selection and VLBI observations of radio-sources for the alignment of the radio and optical reference frames.
- Observations and analysis of reference stars for the calibration of the stellar parametrization algorithms in CU8.
- Ground-Based Observations for Gaia (GBOG) within the cross-CU working group set-up in 2006 to coordinate the DPAC observing proposals and organize the acquisition plan of the auxiliary data needed for the data processing.
- Morphology analysis of extended objects such as the millions of galaxies to be observed by Gaia, and characterization of the spatial environment of QSOs, searching for structure perturbing their astrometric solution.

It is worth noting that our 130 years old Meridian Circle, now fully automated and observing in TDI mode, still delivers positions to improve the astrometric reduction of the Ecliptic Pole Catalogue to be used during the Gaia initialisation phase.

From left to right : C. Ducourant, J.-F. Lecampion, T. Jacq, S. Blanco-Cuaresma, N. Brouillet, C. Soubiran, G. Bourda, L. Chemin, P. Charlot, P. Jofre-Pfeil. Missing : F. Billebaud.

The Catania Astrophysical Observatory and Dept. of Physics and Astronomy *by A. Lanzafame*

The Catania Astrophysical Observatory (OACt) dates back to 1879-1890, when the "Osservatorio Bellini" was built on mount Etna and a city site was established in a part of the former "Benedettini" monastery. In the mid 1960's, the main site moved to a new building on the University campus and a new mountain site was built.

The Observatory is today one of the structures of the Italian National Institute for Astrophysics (INAF) and hosts about 30 astronomers, 7 post-docs, 5 Ph.D. students, as well as 30 technicians and admin staff. The academic staffs of the Astrophysics Section of the University's Department of Physics and Astronomy have their offices in the same building.

Eleven OACt scientists and one Ph.D. student contribute to the DPAC activities. Among them, there are one University staff (UniCt) and three affiliated members. The group is mainly involved in CU7 and CU8, but it supports also CU3 activities in close collaboration with OATo.

In CU7, the group defines and implements methods for the detection and analysis of rotational modulation induced by star-spots and flares in solar-like stars, for both the "special variability detection" and "specific object studies" packages. Alessandro Lanzafame has also a management role in the "special variability detection" packages, i.e. variability requiring non-standard approaches, which also includes the detection of transits of extra-solar planets and more generally the detection of small amplitude variations over short duty cycles.

In CU8, the group is responsible for the extended parameterisation of cool-stars, particularly those showing chromospheric activity like young and fast-rotating ones.

The contribution to CU3 concerns the parallelisation of the Global Sphere Reconstruction (GSR) code in the context of the Astrometric Verification Unit (AVU).

The OACt/UniCt group is composed of (*front row starting left)* : Antonino Francesco Lanza, Antonio Frasca, Alessandro Lanzafame, Giuseppe Leto, Giuseppe Cutispoto, *(second row starting left)* Elisa Brugaletta, Innocenza Busà, Elisa Distefano, Ugo Becciani, Sergio Messina, Isabella Pagano. *Not in the picture:* Gaetano Scandariato.

For more info, visit: http://www.oact.inaf.it

Radial velocities for the HTPM project

by Jos de Bruijne and Christina Eilers, European Space Agency (ESA/ESTEC)

The Hundred-Thousand-Proper-Motion (HTPM) project is part of the first intermediate Gaia release, foreseen two years after launch. Its goal is to determine the proper motions of the ~113,500 brightest stars in the sky using Hipparcos astrometry for the first epoch and early Gaia astrometry for the second. The HTPM catalogue will improve the Hipparcos proper motions by a factor ~20.

For fast-moving, nearby stars, it is essential to know the radial velocity to correct the proper motion for perspective acceleration. This correction was applied to the Hipparcos proper motions for 21 stars and the same will be done for Gaia, albeit for a larger sample of stars. The object for which perspective acceleration is largest is HIP 87937, or Barnard's star.

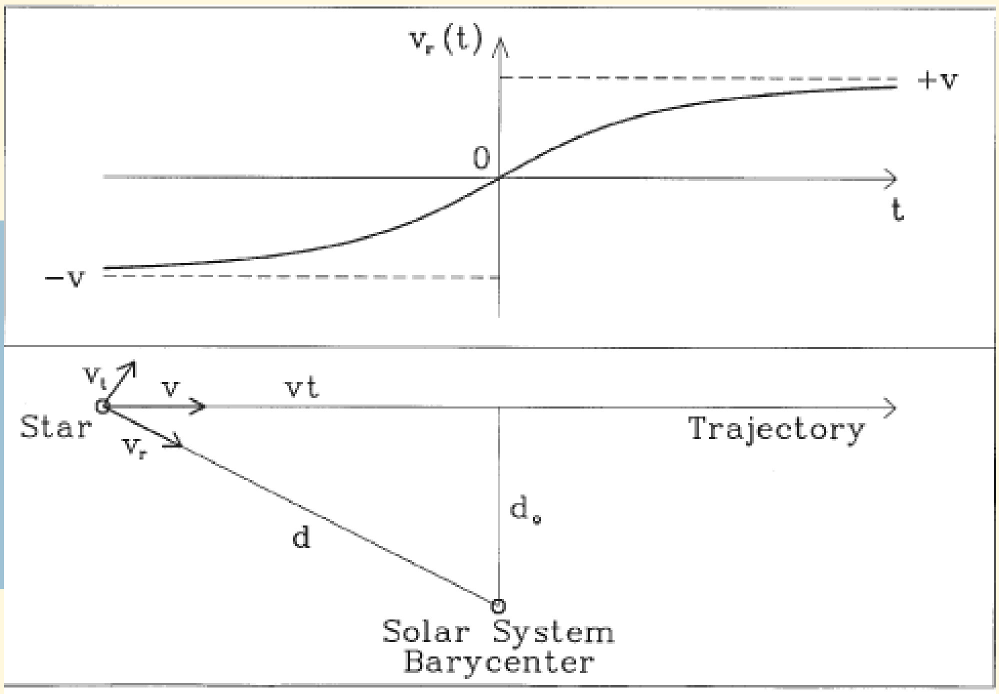
Just a few months after its discovery, Schlesinger (1917) published a paper "on the secular changes in the proper -motions and other elements of certain stars", deriving the order of magnitude of the effect for Barnard's star: +0.0025 arcsec per century in parallax, +0.5 km/s per century in radial velocity, and +0.105 arcsec/year per century in proper motion. The secular evolution of the radial velocity and parallax are tiny: nonetheless, that of the parallax (known today to be +34 muas per year) will be detectable by Gaia and that of the radial velocity (+4.515 m/s per year) has recently been firmly detected in radial-velocity data spanning 25 years (Choi et al., arXiv:1208.2273).

The secular evolution of the proper motion (more than 1 mas/year per year), on the other hand, is large: it was detectable by Hipparcos and will also be "seen" by Gaia. Perspective acceleration also needs to be accounted for in the derivation of the HTPM proper motions and radial velocities are hence required for a few thousand nearby, fast-moving stars.

We conducted a study (2012, A&A 546, A61) to establish for which stars the literature radial velocity and associated standard error are sufficient to guarantee a negligible perspective-acceleration-induced error in the HTPM proper motion. For stars without a literature radial velocity, we established whether – and, if yes, with what standard error – a radial velocity needs to be acquired. Our study indicates that for 97 stars, the radial velocities available in the literature are insufficiently precise. We also identify 109 stars for which radial velocities are currently unknown and need to be acquired. Most stars have visual magnitudes between 8 and 12, K and M spectral types, and southern declinations.

The required radial-velocity measurement precisions are typically modest (<25 km/s), but ten objects require radial velocities with errors less than 1 km/s. Barnard's star is most demanding, requiring a radial-velocity precision of 40 m/s, a level which is non-trivial to achieve in view of gravitational redshift (e.g., 636 m/s for the Sun), convective blueshift (e.g., ~300 m/s for the Sun), unknown (planetary) companions (e.g., ~120 m/s semi-amplitude for a hot Jupiter orbiting a solar-like star in a circular, edge-on orbit with a period of 5 days), etc. Another demanding object is HIP 57367, a nearby, fast-moving white dwarf. The radial velocity for this object, exhibiting a featureless spectrum dominated by a handful of broad helium lines and some weak carbon features, will be notoriously difficult to measure yet needs to be known with a precision of 0.85 km/s.

We are currently in the process of identifying non-published radial velocities of the 206 "problem stars" and have already been able to secure (not-yet-published) radial velocities for 19 objects from the Radial Velocity Experiment (RAVE). A next step is to investigate within CU6 whether the HTPM project could use (pre-release) radial velocities from Gaia's own spectrograph, the RVS, based on a preliminary wavelength calibration.



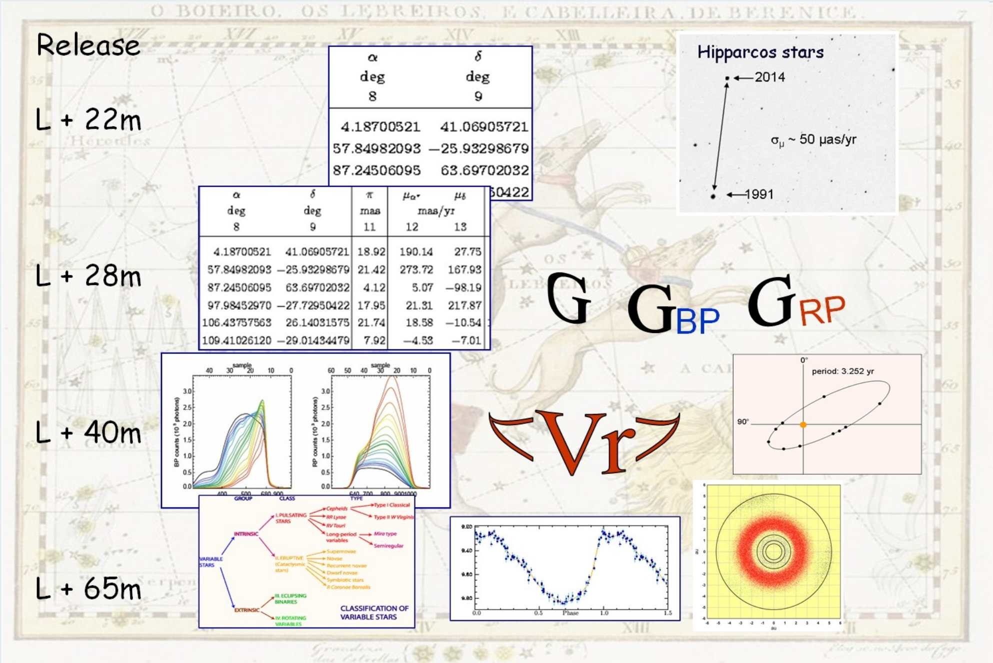
Geometry of the space motion of a passing star (from Kürster et al. 2003). Secular evolution of the observed motions of stars is nothing else than the continuous exchange of proper motion into radial velocity as stars (have) pass(ed) the Sun. This continuously happens for all stars in the sky: the radial velocities of all stars in the sky systematically increase with time …

Gaia Intermediate Data Releases

by François Mignard (OCA) & Timo Prusti (ESA)

Unlike Hipparcos, it has been planned very early during the preparation of the data processing, that results following from Gaia observations should be released to the scientific community before the end of the mission. For a mission whose scientific core involves a global processing of all the photons collected this was somewhat challenging. However, there are areas where this is actually feasible and given the extraordinary improvement in astrometric accuracy with Gaia, even the global astrometric solution is eligible for intermediate releases.

Over the last two years the GST and the DPAC have worked closely together to shape a realistic plan matching the targeted releases to the DPAC operations plan. The DPAC operations are strictly constrained by the stepwise structure of the data processing, the need to complete an extensive calibration of the instruments and have a first global iterative solution available to reconstruct Gaia orientation in space, a prerequisite for several other treatments. There are also obvious astronomical constraints, like no reliable parallaxes can be expected before at least 18 months of data is analysed, or no double star orbit is achievable without a significant accumulation of observations.



Summary schedule and content of the planned intermediate releases for Gaia.

The overall principle has been defined already in the mission Science Management Plan (SMP) approved by the ESA Science Program Committee in October 2006.

It is stated that,

> *"The final mission catalogue products, to be made available to the community, will not be available until the end of the post-operational phase, in around 2020. However, it is important that the astronomical community will have access to the Gaia data, through intermediate catalogues, as soon as a reasonable preliminary calibration is established, while the final mission products with the final instrument calibrations will follow in 2020."*

while the organisational aspect (content, schedule) is delegated to the GST and DPACE:

> *"These intermediate results and final data catalogues will only be released for wider community exploitation once validated and documented. The precise content and schedule of such early releases will be defined at a later date by the Gaia Science Team, in consultation with the Data Processing and Analysis Consortium executive committee".*

Regarding the contents, a first position catalogue covering the whole sky should appear with the 1st release 22 months after the launch (L+22m) together with a special solution for the proper motion of the Hipparcos stars. At the second release (L+28m) we plan a first 5-parameter astrometric solution accompanied by the corresponding G, G_{BP}, G_{RP} integrated magnitude, and radial velocities for stable sources. Then in the next release (L+40m) more spectrophotometric information will be provided and the first orbital solution for short period binary systems. Finally in the last intermediate release (L+65m) one should see variable star classifications and solar system data with orbital solutions. The detailed content of each release can be found in GAIA-CG-PL-ESA-TJP-011-01.

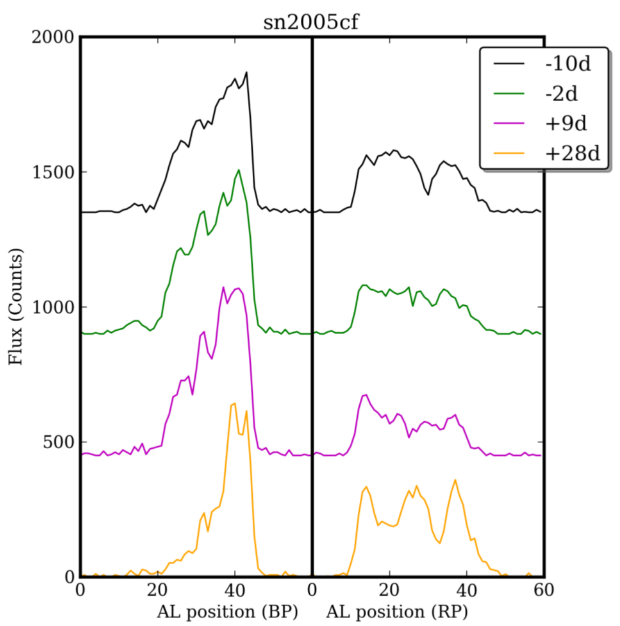
These are the exciting objectives that the DPAC is committed to reach. Very timely, in a few weeks ESA will release an AO for the formation of a new Coordination Unit (the CU9) in charge of developing the tools to allow the community to access and interrogate the Gaia intermediate releases and the final Gaia archive.

Nadejda Blagorodnova, Institute of Astronomy, United Kingdom

Nadia is a Ph.D. student in the Institute of Astronomy (University of Cambridge) within GREAT-ITN network, funded from the European Union Seventh Framework Pro- (FP7/2007-2013) under grant agreement no. 264895, working within WP6 - Grand Challenges: Distances and Transients. Her work is being supervised by Dr. Nicholas A. Walton and Prof. Mike Irwin.

The sky is anything but static. Well sampled observations reveal a great amount of variable and transient phenomena: Supernovaes (SNe), Novae, Microlensing events, Luminous Blue Variable outbursts and Tidal Disruption Events, among others. Gaia will be capable of detecting some of these events, as it will make an average of 78 observations of each object. However, in the challenging world of transients, the speed of alerting and a priori information on the transient characteristics becomes a key to a successful follow-up program.

Transient detection is relatively easy. The main challenge is their rapid classification. Gaia will be able to do this using its Blue (BP) and Red (RP) Photometer low-resolution spectra. Such a powerful classifier needs to be "calibrated", which implies assembling examples of synthetic templates and real observations, covering the temporal evolution of transients. Spectra cross-correlation and Bayesian inference is used to determine the likelihood maps for different set of objects at different redshifts, epochs and reddening values, and therefore select the best winning candidates. These results will be complemented by information extracted from the shape of the Gaia light curve and transient environmental information coming from existing catalogues.



Example of how SNe spectra will be "seen" by BP and RP photometers. In this case it displays the same SNe type Ia: sn2005cf, at different epochs: -10, -2, +9 and +28 days after maximum brightness. Even with low resolution, the broader spectral features are still conserved and can be identified in the classification process. X axis: along scan (AL) pixel. Y axis: flux in counts (with offset). Simulation at G(mag) =17 made using CU5 *XpSim* software.

Calendar of next DPAC related meetings

7-9 Nov	Geneva	CU7: Variability Processing #15	L. Eyer
19-21 Nov	Heidelberg	GBOT #5	M. Altmann
26-28 Nov	Lisbon	CU4: Object Processing #14	D. Pourbaix
28-29 Nov	Astrium	AGIS #18	U. Lammers / S. Klioner
29-30 Nov	Astrium	REMAT #11	S. Klioner / U. Lammers
3-5 Dec	Toulouse	CU6: Spectroscopic Processing #14	P. Sartoretti
4-14 Dec	ESAC and other	DPAC/SOC Operations Rehearsal #2	A. Brown / R. Guerra / others
15-16 Jan	ESTEC	DPACE #16 (joint GST #40)	A. Brown
16-17 Jan	ESTEC	GST meeting #40 (joint DPACE#16)	T. Prusti

Gaia and related science meetings

4 - 8 November	Champaign, Illinois	XXII Astronomical Data Analysis Software and Systems (ADASS)	http://www.ncsa.illinois.edu/Conferences/ADASS2012/
5 - 7 November	Torino	Gaia and Exoplanets: GREAT Synergies on the Horizon	http://www.oato.inaf.it/astrometry/Gaia_Italia/Partecipazione_Italiana/Convegni/Futuri/GREATWorkshop2012/index.html

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