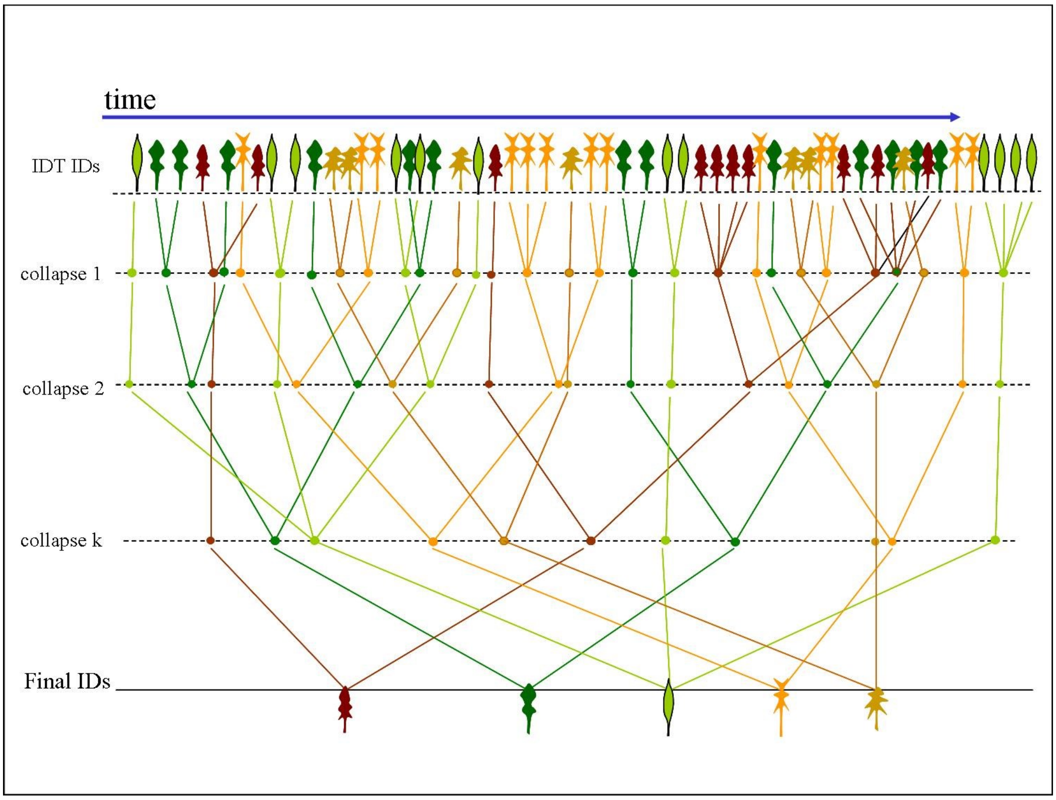
Newsletter 23

25 APRIL – 2014



Step-by-step matching between the observations and the small solar system bodies. A set of 5 asteroids is gradually matched to observations over short time spans, then these groups are combined together until a good orbit allows to gather all the observations of a source under the same ObjectId. Also see p7.

IN THIS ISSUE:

Editorial by DPAC chair,

The start of 2014 has turned out to be exciting indeed for DPAC! The issue of the previous newsletter was just after Gaia had been inserted into its orbit around the famous L2 point. The commissioning of the scientific instruments then started in earnest with a beautiful image of NGC 1818 released on February 6, showing how Gaia is coming into focus and demonstrating its great sensitivity and image quality.

As will be detailed in the DPAC news section the commissioning of Gaia has been successful so far with the exception of a couple of unpleasant surprises which have caused the commissioning campaign to take longer than expected. The nominal Gaia mission is now expected to start in June.

The operations at the data processing centres at ESAC and in Torino are in full swing, with the results of the early data treatment being pushed to other centres, and to the Payload Experts who are very effectively supporting the commissioning campaign with in depth analyses of data from all instruments.

Meanwhile the data processing centres in Cambridge and Toulouse are gearing up for the performance verification phase in commissioning, when the advanced treatment of data from the photometric and spectroscopic instruments will kick off. The processing centres in Barcelona and Geneva are looking ahead toward the longer term when the DPAC cyclic processing will start. A first major exercise focused on simulating the cyclic processing and the production of a data release is planned for later this year.

The Gaia commissioning campaign will be closed off with a detailed performance assessment on which I hope to report in the next newsletter.

Gaia project and DPAC News

A. Brown

It is now four months since the launch of Gaia and DPAC has been very busy supporting the commissioning campaign by processing the telemetry coming down from the spacecraft, analysing the results, and supporting the Airbus Defence & Space (formerly EADS Astrium) industrial team by providing them data and feedback on commissioning activities. The teamwork between DPAC, ESA, the Science Operations Centre at ESAC, the ESOC team, and Airbus D&S has been excellent. Below the commissioning status is summarized and some further news on DPAC data processing is provided.

Successful early in-flight qualifications

The work done to bring online all components of the Gaia service module, which houses equipment needed for the basic control and operation of the satellite, has gone very smoothly. The chemical and micro propulsion systems function well, with the latter providing tiny (micro-Newton!) thrusts to maintain Gaia's spin rate, compensating for torques due to solar radiation pressure. The phased array antenna is operating very well, ensuring that we can maintain the high data rates that are needed to downlink all the science data. And the essential rubidium atomic clock is also working to specification. The high accuracy verification of the overall time correlation performance is pending.

The Gaia scientific payload is also functioning very well. This includes all 106 CCD detectors and the associated electronics units, as well as the seven on-board computers that manage the CCD's. Alignment and co-focusing of the two telescopes through their movable secondary mirrors is working as expected. Following the last displacement of one of the secondary mirrors by just 3 micrometres, we are currently at the optimal image quality that Gaia can deliver, well balanced across the large focal plane and the three instruments. This is no small achievement considering the complexity of the optics!

A couple of unexpected behaviours

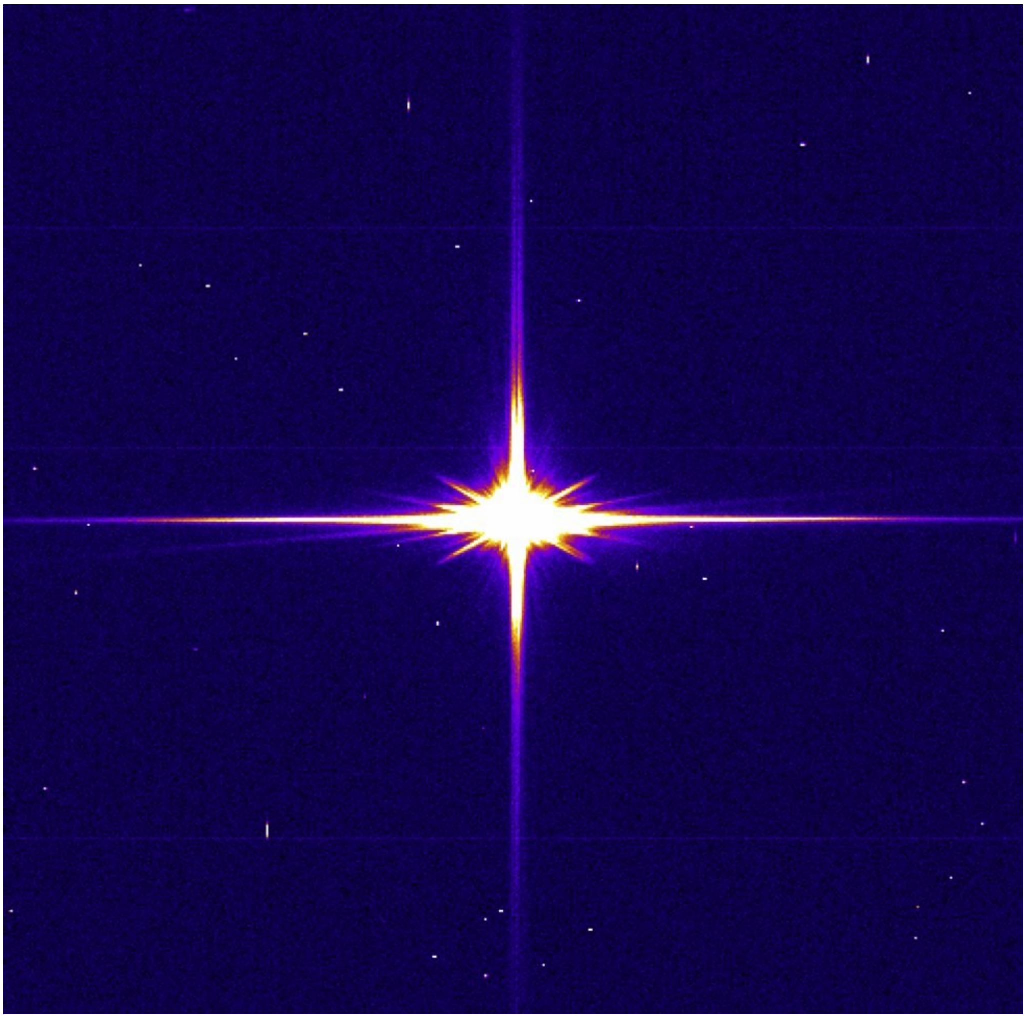
However, a few other aspects of the commissioning have been progressing somewhat less smoothly.

In order to deliver exquisitely precise measurements of the positions of stars on the sky, we need in turn to know where Gaia itself is in space very accurately at any given moment. The distance part of Gaia’s orbit is readily determined from radio signals sent back and forth, but the position on the plane of the sky needs ground-based telescope observations of the satellite. It turns out that Gaia is much fainter in the sky than hoped for, at magnitude 21 rather than 18, and thus the smaller 1 metre diameter class telescopes planned to be used by Gaia's GBOT network are not big enough to detect Gaia in a reasonable amount of time. But by shifting the bulk of the observations to the 2.0-m Liverpool Telescope on La Palma and ESO's 2.6-m VST on Paranal, as well as introducing Very Long Baseline Interferometry radio measurements, the problem is now under control.

Near the beginning of commissioning, a steady drop in the transmission of Gaia's telescopes was seen, due to water-ice deposits building up on the mirrors as trapped water vapour was liberated from the satellite after launch. The transmission was fully recovered following a decontamination campaign, during which the payload was heated to remove the ice from the optics.

Ice deposits are thought to play a part in another concern, in which unanticipated ‘stray light’ is seen hitting parts of the Gaia focal plane. Some of the stray light is thought to come from sunlight diffracted around the edges of the sunshield and entering the telescope apertures. There also seems to be a smaller contribution from night sky sources reaching the focal plane via unexpected paths.

Although the diffracted sunlight component was foreseen, we think that it is enhanced by reflections off ice deposits on the ceiling of the ‘thermal tent’ structure surrounding the payload, allowing



Gaia open its eyes in early January delivering few calibration images like this one. The star is alpha Aquarii observed in the Sky Mapper with a 2.85 s exposure. Although the telescope is not yet tuned to the best focus, the image is already very sharp with the details of the diffraction pattern of the rectangular pupil clearly visible. As a 3rd-magnitude star and with full exposure, this source is much too bright for Gaia and unsurprisingly the pixels are oversaturated. credit ESA/DPAC/Airbus DS

it to reach the focal plane. It was hoped that the decontamination campaign would also remove this ice layer, but unfortunately the stray light is still there at the moment.

Careful preparations are being made for one more attempt to remove the water ice and, hopefully, the stray light. But in parallel, we are now continuing with the nominal commissioning programme. This means that over the coming weeks the detailed performance verification phase of Gaia will be conducted and that we can expect the first one-day astrometric solutions. These will be crucial in demonstrating Gaia's astrometric potential.

It should be stressed that even if the stray light remains, the current assessment is that the degradation in science performance will be relatively modest and mostly restricted to the faintest of Gaia's one billion stars.

DPAC system meets its challenge

In parallel to all the activities on the spacecraft the DPAC systems are undergoing their own commissioning. The Initial Data Treatment and First Look systems, which process the data from all of Gaia's instruments, have coped well with the data volume so far, even while undergoing many upgrades and patches.

The same holds for the Astrometric Verification Unit's systems, which independently treat the data from the Basic Angle Monitoring device and the astrometric instrument. The data processed so far comprises about 2 TB of telemetry, implying that we have already processed over 1.5 billion images of stars and other sources! The true stress testing of the data processing systems will start soon when in the performance verification phase much more data is expected to come down from Gaia.

It has been an exciting four months with lots more happening than can be summarized here, and we look forward to the end of the commissioning phase and the start of nominal operations for DPAC.

Coordination Unit 2 C. Babusiaux & E. Masana

The development of the Gaia simulator started 15 years ago now. It has been used for mission design, performances prediction, data processing software testing and validation.

The simulator is build around an Instrument Model, simulating all the relevant components of the satellite and its instruments, and a Universe Model (also see DPAC NL 11 article A. Robin), simulating all objects expected to be observed by Gaia and their properties. Three data generators have been built using those models:

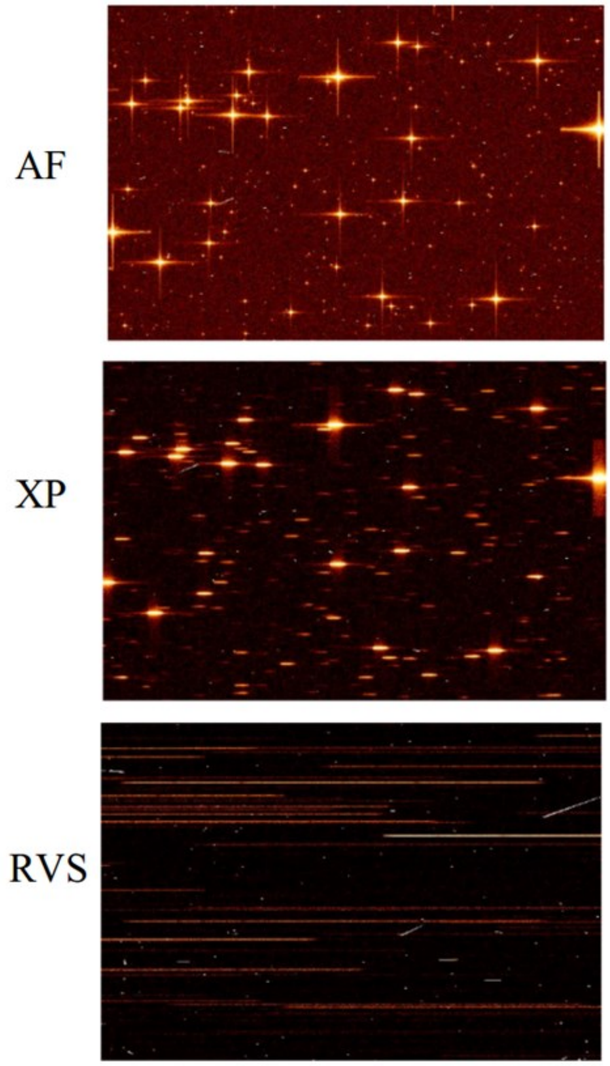
- GASS (Gaia System-level Simulator) provides simulations of the telemetry stream of the mission, allowing a large amount of data to be simulated over a significant period of time.
- GIBIS (Gaia Instrument and Basic Image Simulator) designed to generate simulations at the pixel level, providing images and on-board processing as realistic as possible of a sky region.
- GOG (Gaia Object Generator) delivers simulations of the intermediate and end-of-mission Gaia data on a source by source basis, simulating the outputs and the accuracies of the main stages of the data processing.

GASS and GOG large scale simulations are run at the Barcelona Supercomputing Center MareNostrum. GIBIS and GOG are deployed at CNES and can be run through a web interface.

The Simulator tomorrow

With the arrival of the real data, the CU2 activities have strongly decreased and now concentrate on simulations for the downstream CUs (CU4,7,8) and for CU9 (preparation for the data delivery and validation). The main still active CU2 members are from Spain and France.

Fig 1: GIBIS images of an open cluster as seen by the three Gaia instruments



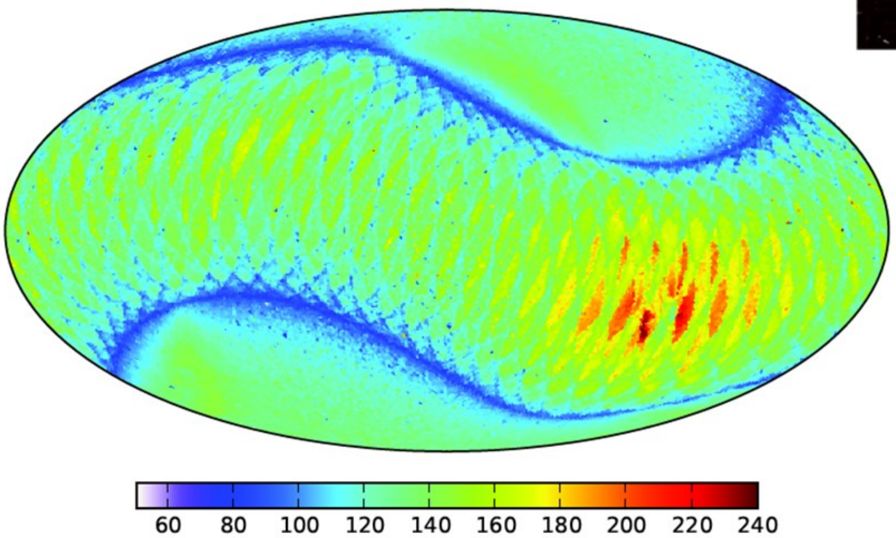


Fig 2: GOG sky map of the mean parallax error (in µas) in equatorial coordinate. The red area corresponds to the bulge region. The map is obviously dominated by the large number of faint stars in the Gaia survey.

KOUROU

F. Mignard

Who is in charge at the Kourou spaceport ?

Those who attended the Gaia launch in Kourou did not fail to notice a peculiar share of responsibilities in the spaceport between the French Space Agency (CNES) indisputably at home there, ESA being clearly more than a simple user or customer and Arianespace which is visible everywhere on the site, even more than the other two. This seemingly intricate, but successful, 'ménage à trois' can only be understood with a look at the historical development of the Kourou spaceport.

Kourou and CNES

In the early days of the French Space program, say between 1950 and 1965, launches were executed from Hammaguir, a military centre located in Western Algeria, still a French department at that time. When Algeria gained its independence in 1962, and despite a secret clause in the war settlement granting access to France for the next five years, the just founded CNES searched actively for a long term solution for its program. Fourteen potential sites were prospected in areas as attractive as the Caribbean, French Guyana, Ceylon, Darwin in Australia, Belem in Brazil, East Africa and Madagascar before the choice fell on the French Guyana. Among the key elements which led to this choice, one must mention a location very near the equator, large opening in launch directions toward east, good climate for an equatorial site, a sparsely populated area and political stability. The official decree was signed by G. Pompidou, the then French Prime Minister, on the 14th of April 1964. The Guyana Space Centre starts officially in Kourou in 1965 and the first French launch from Kourou took place in April 1968.

Kourou and ESA

ESA established in 1975 when ten European states decided to unite their effort into joint space program, including the development of a European launcher. France offered to share Kourou with ESA, while ESA brought funding to upgrade the launch facilities and prepare the spaceport for the European Ariane launcher. The first launch of Ariane 1 came about on the eve of Christmas 1979, giving ESA an autonomy to launch and deploy scientific and commercial satellites. This paved the way for a lasting partnership, with ESA funding two-third of the annual running expenses and making massive investments to meet the ambitious European Space Program. New facilities, among them the Vega and Soyuz launchpads have been totally financed by ESA. While the site is formally French, ESA owns the special infrastructure built for the Ariane launchers, the launcher and satellite preparation buildings, launch operation facilities and a plant for making solid propellant.

Kourou and ARIANESPACE

The last partner, Arianespace, is a French company founded in 1980 as a commercial space transportation company which markets and operates launches, most of them for the telecommunication not related to ESA own program. CNES, although the single largest shareholder of Arianespace, is just one among 21 from 10 European states. Arianespace is also tied to the Russian Federal Space Agency (Roskosmos) through an agreement with ESA allowing the launch of Soyuz rockets from Kourou, including VS06 carrying Gaia. To make things simpler, Arianespace does not manufacture (at least since 2003) the Ariane rockets which is done by Airbus Defence and Space for ESA which remains at the helm of the Ariane program. Arianespace has permanent offices in Kourou and industrial facilities shared with ESA on the site.

Finally the Spaceport is in France and ruled under French law. The in-site security is assured by a Guyana unit of the French army while a squadron of gendarmerie is responsible for the security around the site. Interestingly, fire security and firefighting are entrusted to a detachment of the Paris fire brigade.

Looks simple, isn'it ?

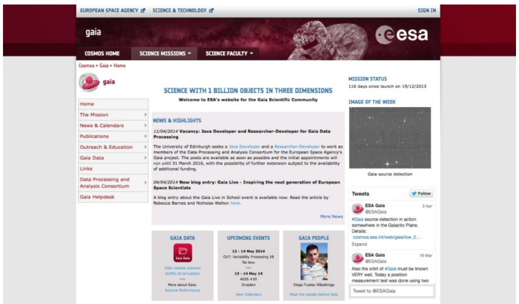
The size, position and variety of logos on this model of Ariane 5 which welcomes the visitors at the main gate of the Kourou space centre, provides a conspicuous testimony of the complex entanglement of partnerships.

Gaia on Cosmos: a facelift for the community website

S. Vogt

Regular users of the Gaia DPAC online tools will have already noticed the new look and feel of the community site. In November 2013 the website for the scientific community moved from the ESA RSSD to the new Cosmos environment. In the process the pages did not only get a fresh design, new URLs and additional content, but also a new navigation menu and structure.

The website overhaul coincided with the launch of Cosmos, ESA's new portal for teams working on the Agency's Science missions. As part of Cosmos, the Gaia pages make use of the new infrastructure and environment provided by the ESA Science Operations Department and the Scientific Support Office.



The Gaia website for the scientific community can be found at cosmos.esa.int/gaia.

In the coming months, more and more DPAC tools will move to the Cosmos area, so that the old "My Portal" section on the RSSD server will disappear in the long run. Currently, services such as Livelink, Mantis and the Gaia People editor can only be accessed through the "My Portal" interface which requires an additional login. Integrating the tools into Cosmos will make this step unnecessary and will provide additional user benefits such as improved user-interfaces and features. Work on this is in progress and is expected to last until late 2014/early 2015.

You can access the Gaia pages at: cosmos.esa.int/gaia. DPAC members can log in using the "sign in" button in the upper-right hand corner of the homepage. After a successful login, the tab "DPAC Services" appears in the navigation menu. Here you find all the tools available for your DPAC work. Besides access to these services, the Gaia website also provides news about the mission to the wider scientific community, information about Gaia's science and, at a later stage, access to the catalogues. It also hosts the DPAC pages and features a media gallery as well as various education and outreach materials.

If you have any suggestions or comments about the website, or if you would like an "Image of the Week" or "Gaia People feature" to be published, please send an email to: gaia-helpdesk@rssd.esa.int.

Access to the world of Gaia: the Non-Disclosure Agreement

S. Vogt

In December 2013 all DPAC members, including affiliate members and collaborators, were asked to sign the Gaia "Non-Disclosure Agreement and declaration of non-violation of Gaia data rights rules" (NDA). The agreement concerns the use of Gaia raw data and data products outside of Data Processing Centres (DPCs). It also covers CU9 activities. At the end of January 2014, a total of 559 DPAC members, including 71 affiliates and 12 collaborators, had submitted their NDAs.

Jointly agreed by the DPAC Executive and the Gaia Science Team, signing the NDA is mandatory for maintaining or obtaining the DPAC membership. Like all current DPAC members, affiliates and collaborators, all new members have to sign the agreement since Gaia data, or products derived from them, may appear in DPAC tools such as SVN, Mantis or the Wiki which are (partially) accessible to all members.

The Non-Disclosure Agreement stipulates that DPAC members shall use and examine the Gaia data solely for the purposes and tasks entrusted to them through DPAC. By signing the agreement, members agree that data, which have not been officially released yet, shall not be used for any scientific exploitation work, or in any publication or outreach exercise which goes beyond defined DPAC tasks. Signatories also declare to comply with the procedures and rules imposed by the DPAC Executive and ESA concerning access to and use of Gaia data, to keep the Gaia data confidential and secured, and to refrain from sharing them with anyone who has not signed the NDA.

For any questions about the Non-Disclosure Agreement, please contact the Gaia helpdesk at: gaia-helpdesk@rssd.esa.int.

The Non-Disclosure Agreement is made for the benefit of preserving the Gaia Data Rights as determined in the Gaia Science Management Plan ESA/SPC(2006)45.

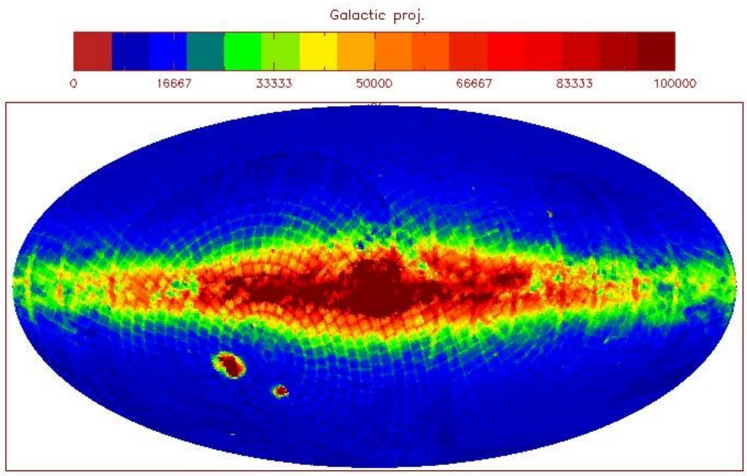
IGSL

R. L. Smart

The Initial Gaia Source List (IGSL) was envisioned to be a compilation of the best optical astrometry and photometry information on celestial objects available today. A snapshot of the sky as we know it before Gaia. In 2011 a decision was taken to make the IGSL the starting point for the IDT cross matching routines to simplify the operational procedures. As a result of this decision it was decided to reduce the size of the the IGSL. Originally the goal was to be as complete as possible - even to a R magnitude of 24 when possible - at a cost of having false objects or being very large. Following the new requirements, the goal was to produce a cleaner smaller catalog and not to go beyond the nominal Gaia G magnitude limit of 21.

We have included all publically available large (e.g. >10000 square degrees) catalogs and some smaller special area or special objects catalogs. As a compilation catalog it benefits of combining objects and parameters from various catalogs but also the disadvantage of combining some errors and problems from the input catalogs. The first version of the IGSL was provided in 2007 and since then has been updated 3 times. On a large scale it is homogenous but there are many individual problem entries that were not found before it was frozen in 11/2013. The delivered version can be accessed via the MDB explorer http://gaia.esac.esa.int/mdbexp/mdbexp/ and delivered to the CDS (I/324/igsl3).

The Gaia G and RVS magnitudes are calculated using the best red and blue magnitudes from the input catalogs. The transformations and priority list is provided in the IGSL documentation Gaia-C3-TN-OATO-RLS-004. In this document there is also a list of known problems which a user should be aware of before using the IGSL for any purpose.



The distribution of objects in the IGSL plotted as a function of galactic position. The outlines of the Schmidt plates that make up the base of the IGSL deep catalogs are clearly visible as well as the footprint of the SDSS DR9 survey. The colors indicate the number of objects per healpix level 6 as shown in the legend.

The IGSL in a nutshell

- **Delivered in September 2013**
- **Number of Objects: 1 222 598 530**
- **Astrometry: Positions, proper motions**
- **Photometry: Gaia G, Gaia RVS, GSC2 R and GSC2 B magnitudes**
- **Included Catalogs:**
  - **GEPC: The Gaia Ecliptic Pole Catalog, version 3.0**
  - **GSC2.3: The Second Guide Star Catalog version 2.3**
  - **LQRF: Large Quasar Reference Frame**
  - **OGLE: Optical Gravitational Lensing Experiment version III**
  - **PPMXL: Positions and Proper Motions ``Extra Large'' Catalog,**
  - **SDSS: Sloan Digital Sky Survey data release 9**
  - **UCAC4: USNO CCD Astrograph Catalog version 4**
  - **2MASS: Two Micron All-Sky Survey Point Source Catalog**

As well as the Tycho-2, Hipparcos, Sky2000 catalogs and the Standard Photometric Sequence Stars from CU5.

How to chain observations of new minor planets

J.-M. Petit, F. Mignard

During its mission, Gaia will survey some 350,000 solar system objects down to 20 mag. The vast majority of these sources will show up as point sources, behaving like stars for the Gaia detectors. It is expected that a small fraction of this set, probably below 5%, will be really new sources, while the other 95% will be already referenced in existing data bases with orbital elements accurate enough to match an observation to a definite source (see the article of J. Berthier in NL21).

For the other sources, the quick motion on the sky will reveal the very nature of the source observed allowing to (hopefully) quickly sort out new minor planets for non-cross matched stars. Assuming this is properly done with only few contaminants, the next step is to match together to a single source all the observations of a new object. This is an essential step to perform latter an orbit determination based on all available observations. This is the task assigned to DU455 of the Solar System Object processing in CU4.

A problem with two timescales

Basically, after several months of observations and a good filtering of the known sources one will have a list of transit times of unidentified sources, assumed to be only new planets. For a particular planet, the transits will appear in general as isolated observations separated by 2 to 5 weeks, or as two closely packed observations in the preceding and then following FOV (more rarely in the FFOV and then the PFOV) until a new group shows up again after few weeks. In the most favourable case a group will comprise more than two successive observations, when observations span several revolutions of Gaia. So there are two different problems related to these timescales :

- linking observations taken within a couple of Gaia revolution periods, which is referred to as the "bundling”

- linking observations widely separated in time, which we call the "threading", like one threads a set a messages on the same topic.

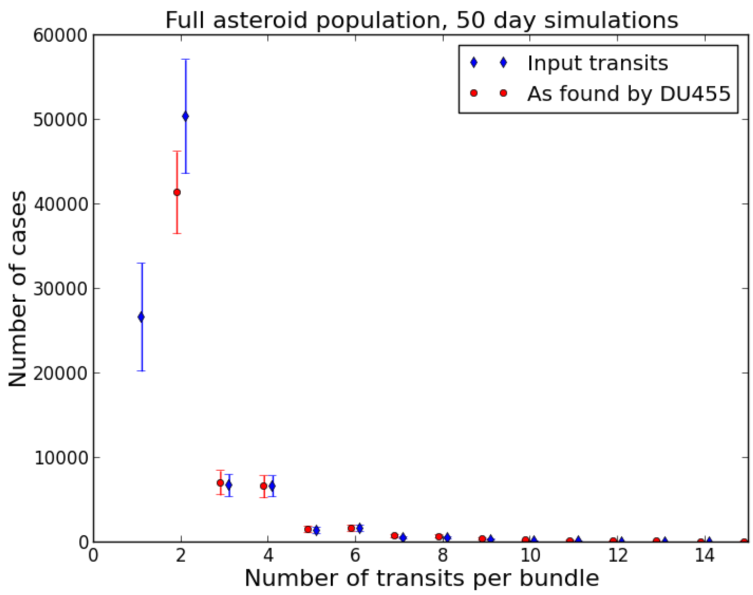
Linking observations on short time scale

If we know the velocity on the sky at each transit, one can extrapolate the position a few hours, or even a few days, in the future with a linear kinematical model. In the absence of this information, which is most often the case, one can extrapolate based on the on-sky velocity distribution for that solar elongation. In all cases, one can predict with sufficient accuracy the time of next observation for the object under consideration. If one observation is found in a small time window around the predicted time, one checks further its magnitude, actual position and possibly velocity to firmly accept it as an observation of the same source. The same applies when more than two observations are found within one, two, ... revolution periods of Gaia.

Linking observations on intermediate time scale (~ few weeks)

With at least two observations, the velocity is considerably improved, and with three or four one can even have an acceleration. The extrapolation model becomes also much reliable and, it can works sufficiently well for several weeks. Even better with few observations spread over one or several days a range of orbital elements can be estimated, allowing an easier match between distant observations located few weeks apart.

Then as soon as two or three groups of observations spanning several weeks are available an orbit can be fitted allowing to link into in single thread all the observations of a new source and assigned a final ObjectID. The whole process is sketched out on the cover page of this issue for a set of five planets.



Number of transits per bundle. A model of all minor planets was used to generate six 50-day simulations of Gaia's detections over a time span of 400 days. Blue errorbars correspond to real bundles from the simulation. Red errorbars show the number of isolated transits per bundle found by DU455. The isolated blue mark for 1 transit per bundle shows the number isolated transits in the simulation which thus cannot be bundled. Points stand for the average of the 6 simulations.

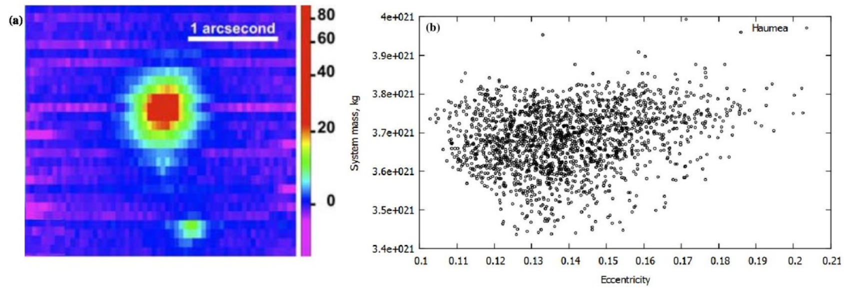
PhD Corner: Irina Kovalenko, IMCCE (France)

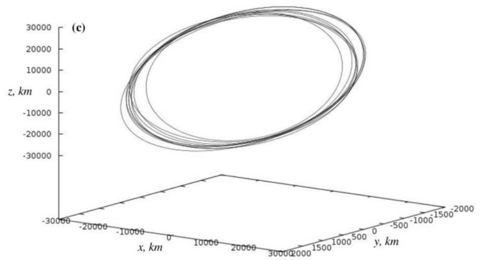
I am a Ph.D student at the Paris Observatory and started to work on "Orbital and Physical Chracterization of Binary Asteroids". The work is supervised by D. Hestroffer (IMCCE) and A. Doressoundiram (LESIA) and supported by Labex ESEP (ANR N 2011-LABX-030).

We focus on the study of binary and multiple asteroids, which Gaia will observe inside various groups: main belt, Trojans, NEOs or TNOs. Combining Gaia data to Herschel and Spitzer observations, we will determine physical parameters such as mass and density of asteroids. The knowledge of such fundamental parameters and the study of this type of object is important for understanding the formation and the evolution of the Solar System.

Gaia will provide during 5 years positional measurements with high accuracy. It will enable to describe the mutual orbit of a binary pair. We will use the statistical inversion techniques for orbit determination which requires at least a set of seven independent parameters (the system mass plus the three-dimensional relative position and velocity vectors). Moreover photometric measurements will provide additional physical parameters such as colours, etc.

Furthermore, Gaia could detect closely-spaced components of binary and multiple systems, at separation larger than approximately 100 mas. Therefore, it will enable the discovery new binary systems and improve the general statistical analysis of physical and orbital properties of binary asteroids.





Example of a multiple system imaged with Adaptative Optics at VLT/SINFONI (Dumas et al. 2011), panel (a). From such similar images and positions, Gaia will yield the orbits and mass of binary asteroids. Here a distribution for a set of possible elements for Namaka's orbit (b), and relative orbit in space for a given subset (c).

DPAC meetings

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

Date	Title	Place	Local Organiser
12 - 14 May 14	**CU7: Variability Processing #18**	Tel Aviv	Zucker
13 - 14 May 14	**AGIS #20**	Dresden	Lammers/Klioner
19 - 21 May 14	**CU4: Object Processing #17**	Toulouse	Pourbaix
22 - 23 May 14	**GBOT #8**	Liverpool	Altmann
26 May 14	**CU1: System Architecture #17**	ESAC	Siddiqui
27 - 28 May 14	**DPC/OR#5 prep meeting**	ESAC	Els
4 - 6 June 14	**CU3: Core Processing #9**	ESAC	Bastian
11 - 12 June 14	**DPACE #19** (12/6 joint GST #45)	ESTEC	Brown
12 - 13 June 14	**GST #45** (12/6 joint DPACE #19)	ESTEC	Prusti
17 - 19 June 14	**CU6: plenary meeting**	MSSL	Sartoretti
25 - 27 June 14	**CU5: plenary meeting**	Leiden	van Leeuwen
7 - 8 July 14	**CU9: plenary meeting**	Vienna	Luri
6 - 7 November 14	**CU8: plenary meeting**	Torino	Drimmel

More information at http://www.cosmos.esa.int/web/gaia/calendars