Gaia outreach features available to the scientific community

Carmen Blasco
Gaia: at the frontiers of astrometry
11/06/2010
Contents

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- For scientists:
  - Public documents
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  - Little Books of Gaia
Gaia factsheet

The Galactic census project

Name

Gaia was originally derived as an acronym for Global Astrometric Interferometer for Astrophysics. This reflected the optical technique of interferometry that was originally planned for use on the spacecraft. However, the working method has now changed. Although the acronym is no longer applicable, the name Gaia remains to provide continuity with the project.

Description

Gaia is a mission that will conduct a census of a thousand million stars in our Galaxy. It will monitor each of its target stars about 70 times during a five-year period, precisely charting their positions, distances, movements, and changes in brightness. Gaia is expected to discover hundreds of thousands of new celestial objects, such as extra-solar planets and failed stars called brown dwarfs. Within our own Solar System, Gaia should observe hundreds of thousands of asteroids.
Fact Sheet

Gaia is an ambitious mission to chart a three-dimensional map of our Galaxy, the Milky Way, in the process revealing the composition, formation and evolution of the Galaxy. Gaia will provide unprecedented positional and radial velocity measurements with the accuracies needed to...
Gaia is an ambitious mission to chart a three-dimensional map of our Galaxy, the Milky Way, in the process revealing the composition, formation and evolution of the Galaxy. Gaia will provide unprecedented positional and radial velocity measurements with the precision needed to...
### Calendar of meetings, conferences & events

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

**Title**

<table>
<thead>
<tr>
<th>Title</th>
<th>Location</th>
<th>Convener(s) / Local organiser(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REMAT #7</td>
<td>Torino</td>
<td>Knöllner</td>
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<tr>
<td>GBDT Software and Observations workshop</td>
<td>Paris Observatory</td>
<td>Altmann</td>
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<tr>
<td>CUB: Spectroscopic Processing #9</td>
<td>Observatoire de Paris</td>
<td>Katz</td>
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<td>MLA steering committee meeting #6</td>
<td>Paris</td>
<td>Prusti</td>
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<tr>
<td>GST meeting #31</td>
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</tr>
<tr>
<td>DPACE #11</td>
<td>CNES</td>
<td>Mignard</td>
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</table>
Web sites: Research & Scientific Support Department

http://www.rssd.esa.int/index.php?project=GAIA&page=Calendar_of_meetings
## Calendar of meetings, conferences & events

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

<table>
<thead>
<tr>
<th>Title</th>
<th>Dates</th>
<th>Location</th>
<th>Convener(s) / Local organiser(s)</th>
</tr>
</thead>
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<tr>
<td>EMAT #7</td>
<td>24-26 June 2010</td>
<td>Torino</td>
<td>Kühner</td>
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<tr>
<td>EMAT #8</td>
<td>27-28 June 2010</td>
<td>Torino</td>
<td>Kühner</td>
</tr>
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<td>EMAT #9</td>
<td>29-30 June 2010</td>
<td>Torino</td>
<td>Kühner</td>
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<td>3-5 July 2010</td>
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<td>19-21 June 2010</td>
<td>Observatoire de Paris</td>
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<tr>
<td>GLA steering committee meeting #6</td>
<td>23-24 June 2010</td>
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<td>Prusti</td>
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<tr>
<td>GST meeting #31</td>
<td>1-2 July 2010</td>
<td>ESTEC</td>
<td>Prusti</td>
</tr>
<tr>
<td>DPACE #11</td>
<td>8-7 July 2010</td>
<td>CNES</td>
<td>Mignard</td>
</tr>
</tbody>
</table>
Gaia library

The library collates selected papers and articles on the Gaia mission, and on scientific or technical topics relevant to Gaia. Included in this section are some key papers describing the project, links to reference documents and a list of acronyms, peer-reviewed papers on scientific topics covered by Gaia (see also astro-ph and ADS search links on the right-hand menu), conference proceedings and publications issued by ESA (see right-hand menu).

1. Livelink (restricted access documents)
2. Public access documents
   2.1. Conference proceedings & reports
   2.2. Selected papers
   2.3. DRAC public documents

Livelink is the Gaia scientific document management system (restricted access documents).

Livelink is the document management system used for scientific documents from Gaia. Livelink is password protected and is intended to be used only by individuals working on Gaia. Users with a personal Gaia user name and password may access Livelink once they have logged on to MyPortal (see right-hand menu).

Quick access to Livelink (you must be logged in to MyPortal to access):
Gaia Livelink: Entry Page

Reference Systems, Conventions and Notations for Gaia
Author: U. Bastian
Published in: unpublished - project document
2.4. DPAC public documents

Multistage probabilistic classification
Author: C.A.L. Bailier-Jones, K. Smith
Document code: GAIA-GN-MPIA-CBJ-037 (project document)
Summary: We present a probabilistic framework for combining classifiers. Each classifier stage may be based on different data (e.g. astrometry, BP/RP spectrum, G-magnitude, Galactic latitude) or types of object (Galactic, extragalactic). Different data types have differing degrees of power in determining the classes. We present two types of combination. The first uses simple probability theory to combine classifications based on spectroscopy only and astrometry only. The second combines two spectral-only classifiers – one for all classes, the other only for Galactic objects (single and binary stars) – using a weighting function which depends on the astrometry. We introduce a simple approach to simulating Galactic astrometry based on the gamma distribution. We use this to train and test an astrometric-only classifier, one stage in a multistage process.
Available to download from here.
Bibtex entry for this abstract

The maximum reachable astrometric precision: The Cramer-Rao limit
Author: U. Bastian
Document code: 2004BASNOCODE (project document)
Summary: This small investigation shall give a concise insight into the theory of astrometric measuring precision.
Available to download from here.
Bibtex entry for this abstract

Description of the Ring Solution
Author: H. Bernstein, S. Hints, U. Bastian
Document code: GAIA-ARI-BST-001 (project document)
Summary: The task First Look Preprocessing (FLP) provides a daily check of the functioning of Gaia on the basis of the scientific measurements of the satellite. Within this task, the Ring Solution is a special algorithm with some resemblances to the Great-Circle Reduction of ESA’s astrometry satellite HIPPARCOS. The observed stars are connected by their astrometric, attitude and calibration parameters so they form a ring on the celestial sphere. Here, the special interest of the Ring Solution is the estimability and the accuracy of an appropriate set of parameters describing all quantities in question.
Available to download from here.
Science Performance

Gaia will perform micro-arcsecond (mas) global astrometry down to 20-th magnitude by linking objects with both small and large angular distance in a network in which each object is connected to a large number of other objects in every direction.

Photometric observations will be collected, at the same angular resolution as the astrometric observations and for all objects observed astrometrically, to:

- enable chromatic corrections of the astrometric observations, and
- provide astrophysical information, such as interstellar reddening and effective temperatures, for all observed objects.

Spectroscopic observations will be collected down to $V = 17$ mag, to:

- provide radial velocities through Doppler-shift measurements using cross-correlation;
- provide astrophysical information, such as interstellar reddening, atmospheric parameters, and rotation velocities, for stars brighter than $V = 13$ mag; and
- provide element abundances for stars brighter than $V = 12$ mag.

In the scientific performance assessments for Gaia, all known instrumental effects are included under the appropriate in-flight operating conditions (temperature, CCD operating mode, etc.). All error sources are included as random variables with typical/average/expected deviations (as opposed to best-case or worst-case deviations). All performance estimates include a 20% contingency margin. This margin is an ESA science margin, neither meant for nor available to the industrial system-level team. The scientific margin is assumed to cover, among others:

- "scientific uncertainties" in the on-ground data analysis, including uncertainties related to relativistic corrections, aberration corrections,
1. Astrometric performance

The end-of-mission parallax standard error, averaged over the sky, for unreddened B1V, G2V, and M6V stars shall comply with the following requirements:

<table>
<thead>
<tr>
<th></th>
<th>B1V</th>
<th>G2V</th>
<th>M6V</th>
</tr>
</thead>
<tbody>
<tr>
<td>V &lt; 10 mag</td>
<td>&lt; 7 μas</td>
<td>&lt; 7 μas</td>
<td>&lt; 7 μas</td>
</tr>
<tr>
<td>V = 15 mag</td>
<td>&lt; 25 μas</td>
<td>&lt; 24 μas</td>
<td>&lt; 12 μas</td>
</tr>
<tr>
<td>V = 20 mag</td>
<td>&lt; 50 μas</td>
<td>&lt; 50 μas</td>
<td>&lt; 100 μas</td>
</tr>
</tbody>
</table>

The end-of-mission systematic parallax errors for unreddened B1V, G2V, and M6V stars shall be lower than 1 μas.

The astrometric standard errors are calculated following the recipe outlined in GAIA-3DB-022. The standard error calculation includes all known instrumental effects, for instrument-related residual calibration errors at ground-processing (DPAC) level, an appropriate calibration error is included. So-called residual "scintillation calibration errors" (e.g., mismatch of the model PSF, sky background estimation errors, etc.), all of which result from the on-ground data processing, are not included. These latter errors are assumed to be covered by the 20% science margin.

A simple performance model, including a V-I colour term representing the widening of the PSF at longer wavelengths, which reproduces the end-of-mission parallax-standard-error requirements listed above for an unreddened G2V star (V-I = 0.75 mag, V-G = 0.16 mag), and which provides a sensible interpolation in between the three data points, is:

\[ \sigma_n [\mu\text{as}] = \sqrt{(9.3 + 558.12 + 4.568 \times z^2) \times (0.986 + (1 - 0.986) \times (V-I))} \]

where

\[ z = \text{MAX}[10^{0.4 \times (4.15 - 15)}, 10^{0.4 \times (9 - 15)}]. \]

For stars brighter than G = 11.95 mag, shorter CCD integration times (through the use of TDI gates) are nominally used to avoid saturation. The MAX function in the equation above allows to ignore this "complication" and provides a constant bright-star parallax noise floor, at \( \sigma_n = 7 \) μas, for stars with G < 11.95 mag.
2. Photometric performance

The end-of-mission photometric standard errors, averaged over the sky, for unreddened B1V, G2V, and M6V stars shall comply with the following requirements:

<table>
<thead>
<tr>
<th>Photometric band</th>
<th>V [mag]</th>
<th>B1V</th>
<th>G2V</th>
<th>M6V</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1M344</td>
<td>15</td>
<td>$&lt; 10$ mmag</td>
<td>$&lt; 15$ mmag</td>
<td>$&lt; 100$ mmag</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>$&lt; 15$ mmag</td>
<td>$&lt; 100$ mmag</td>
<td></td>
</tr>
<tr>
<td>C1M41U</td>
<td>15</td>
<td>$&lt; 15$ mmag</td>
<td>$&lt; 10$ mmag</td>
<td>$&lt; 20$ mmag</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>$&lt; 20$ mmag</td>
<td>$&lt; 200$ mmag</td>
<td>$&lt; 1100$ mmag</td>
</tr>
<tr>
<td>C1M549</td>
<td>15</td>
<td>$&lt; 8$ mmag</td>
<td>$&lt; 8$ mmag</td>
<td>$&lt; 8$ mmag</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>$&lt; 120$ mmag</td>
<td>$&lt; 120$ mmag</td>
<td>$&lt; 120$ mmag</td>
</tr>
<tr>
<td>C1M965</td>
<td>15</td>
<td>$&lt; 20$ mmag</td>
<td>$&lt; 10$ mmag</td>
<td>$&lt; 10$ mmag</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>$&lt; 400$ mmag</td>
<td>$&lt; 150$ mmag</td>
<td>$&lt; 10$ mmag</td>
</tr>
</tbody>
</table>

Note: all requirements at $V = 20$ mag, as well as the requirement at $V = 15$ mag for the C1M344 band, are formally considered as design goals.

The photometric bands defined in the table above are historical in nature (http://adsabs.harvard.edu/abs/2006MNRAS.367..290) and have no direct physical interpretation for actual Gaia photometry, which is based on low-resolution, dispersive, spectro-photometry using the Blue and Red Photometers (BP and RP). With $\lambda_0$ defining the central wavelength of a band and $\Delta \lambda$ denoting the bandwidth (Full Width at Half Maximum), the bands are defined as follows (see also Table 4 in http://adsabs.harvard.edu/abs/2006MNRAS.367..290):
3. Spectroscopic performance

The end-of-mission radial-velocity robust formal errors, averaged over the sky, for unreddened B1V, G2V, and K1IIIEMP (MP = metal-poor) stars shall comply with the following requirements:

<table>
<thead>
<tr>
<th>Spectral type</th>
<th>V [mag]</th>
<th>Radial-velocity error [km/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1V</td>
<td>12</td>
<td>&lt;1</td>
</tr>
<tr>
<td>G2V</td>
<td>13</td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>16.5</td>
<td>&lt;15</td>
</tr>
<tr>
<td>K1IIIEMP</td>
<td>13.5</td>
<td>&lt;1</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>&lt;15</td>
</tr>
</tbody>
</table>

The maximum instrumental systematic radial-velocity error, after calibration, shall be smaller than 300 m/s.

Radial-velocity robust formal errors are calculated following the recipe outlined in GAIA-JDB-022. The calculation methodology requires, for all stars and magnitudes, that one single end-of-mission composite spectrum is first reconstructed by proper co-addition of all spectra collected during all CCD crossings throughout the mission lifetime. A single mission-averaged radial velocity is then extracted from this end-of-mission composite spectrum by cross-correlation with a template spectrum. The spectroscopic performance requirements in the table above refer to this assumed procedure, although it is foreseen in the postmission on-ground data analysis by DPAC to actually derive single-field-of-view transit spectra, and to extract associated epoch radial velocities, whenever this proves possible in practice.

The robust-formal-error calculation includes all known instrumental effects. For instrument-related residual calibration errors at ground-processing (DPAC) level, an appropriate calibration error is included. So-called residual "scientific calibration errors" (e.g., template-mismatch errors, residual errors in the derivation of the locations of the centroids of the reference spectral lines used for the wavelength calibration, etc.), all of which result from the on-ground data processing, are not included.

This table and this figure provide the radial-velocity robust formal error, at the end of the mission, for a variety of stars as function of V magnitude. The data are based on GAIA-OCH-OPM-PS-006 (access restricted to DPAC members) and have been scaled to meet the performance requirements summarised above.
Image & movie gallery

The image gallery contains a selection of images and movies from the Gaia mission. The images are grouped into categories broadly covering Spacecraft, Payload, Service Module, Launch, Science and Operations.

Movies (click here to access 2 movies available)

Spacecraft (click here to access 5 pictures available)

Payload (click here to access 23 pictures available)

- Overview (2)
Welcome to ESA’s web site for the Gaia scientific community. For more about this and other Gaia web sites follow the ‘More about Gaia’ link.

**News & Announcements from Gaia**

**2010-05-11 Post-doc position on Gaia spectrometer pipeline development at the Astrophysikalisches Institut Potsdam (AIP)**

Applications are invited for a post-doc position at the AIP to help develop elements of the spectroscopic pipeline of Gaia. The main task will be to continue the code development of the back-ground model for the Gaia Radial Velocity Spectrometer (RVS), integration and testing of the code, and writing of documentation. The successful applicant will work in close collaboration with the Observatoire de Paris group that leading the development of the RVS data reduction pipeline. The applicant should have experience with spectroscopic data and code development and preferably have a research profile related to Gaia science.

The initial appointment will be for one year, with extension to a second and a possible third year foreseen. Review of the applications will start immediately and continue until the position is filled. Salary is based on the German public service scale (TV-L; included are employer contributions to medical and dental insurance, maternity leave, and retirement benefits). The AIP is an equal opportunity employer and particularly encourages applications from women. It values diversity. For further questions please contact Dr. Roelof de Jong. More details can be found at the following web site.

**2010-05-03 Postdoctoral position related to open clusters and Gaia in Bordeaux**

The Laboratoire d’Astrophysique de Bordeaux (LAB) carries out observational, interpretative and theoretical research in various fields of astrophysics. In this context, applications are invited for a post-doctoral fellow to work on several research topics, including astrometry and spectroscopy of open clusters and young associations for probing the galactic disc in the perspective of Gaia. For more information, visit the following web page. Deadline for applications: June 1, 2010.

**2010-04-29 Release of the new issue of the DPAC Newsletter**

The DPAC Newsletter no. 8 is now available and there you will find information about the Critical Design Review of the Relay Module, how DPAC Software and Observations
Gaia Posters

A number of general posters have been produced about the Gaia mission. Most of these were prepared by Jane Douglas, Young Graduate Trainee in the Gaia Project Scientist’s Support Team, 2006-2007. The posters are available as pdf files in A1 format (594mm x 841mm); they can be scaled to any reasonable size for printing. Click on the image thumbnail, or the pdf link, to download the file.

Gaia Mission Poster

Produced by: ESA Science
Available in a number of formats here

Industrial involvement in the Gaia spacecraft

Produced by: C. Blasco
Available as pdf file (15M).

Gaia Mission Overview

Produced by: J. Douglas
Available as pdf file (19M).

The Gaia Spacecraft and Instruments

Produced by: J. Douglas
Available as pdf file (16M).
Accurate

Download all Accuracy Information Sheets as one pdf file [here] (603k).

Individual Accuracy Information Sheets:

Astrometric Accuracy Assessment
Download: [pdf] (520k)
Created: 2003-09-30
Updated: 2009-08-25

Astrometric Accuracy Assessment: Results
Download: [pdf] (31k)
Created: 2003-09-30
Updated: 2009-08-25

Astrometric Data Reduction
Download: [pdf] (70k)
Created: 2010-01-27

Gaia Data Access and Analysis Study [OBsolete, superseded by "Astrometric Data Reduction"]
Download: [pdf] (237k)
Created: 2003-09-30
Updated: 2005-02-13

Data Analysis Principle [OBsolete]
Download: [pdf] (23k)
Created: 2004-06-15
Updated: 2009-08-25
Los Minilibros de Gaia

Los Minilibros de Gaia son breves monografías acerca de la misión Gaia, para imprimir sobre folios A4 y plagar en forma de pequeños cuadernos. Están disponibles en PostScript (comprometido con gzip o sin comprimir) y en pdf.

Leer los "Minilibros de Gaia"...

Les Petits Livres de Gaia

Les Petits Livres de Gaia son resúmenes de formato A4 sobre la misión Gaia. Los pueden ser pliés sous la forme de petits livres. Ils sont disponibles ci-dessous en format PostScript (non comprimé ou comprimé avec gzip) et en format PDF.

Lire les "Petits Livres"...

Os Pequenos Livros de Gaia

Os Pequenos Livros de Gaia tratan de diferentes aspectos relacionados con la misión Gaia. São resumos que se imprimem numa página A4 e que se dobram na forma de livrinhos. Estão disponíveis em PostScript (comprimido com gzip ou sem comprimir) e em pdf.

Ler os "Pequenos Livros"...

De Kleine Gaia Boekjes

De Kleine Gaia Boekjes zijn samenvattingen van het Gaia project, elk 1 A4-tje groot. De boekjes ontstaan door het papier op een bepaalde manier te vouwen. De boekjes zijn beschikbaar in PostScript formaat (ongecomprimeerd of gecomprimeerd met behulp van gzip) en in PDF formaat.

Lees de Kleine Boekjes...

Die Kleinen Gaia-Bücher

Die Kleinen Gaia-Bücher sind Zusammenfassungen der Gaia-Mission auf DIN-A4 großen Seiten, die sich zu kleinen Büchlein zusammenfalten lassen. Diese
Conclusions

- There are many resources available for you to make use of them
- Feedback and collaborations are welcome