

“Solar System science before and after Gaia”

Pisa, Italy, May 4-6

Final report

Summary

By performing a systematic survey of the whole sky down to magnitude $V = 20$, Gaia will be able to survey through repeated observations spanning over 5 years several 100,000s asteroids. It will directly measure sizes of about 1,000 objects, obtain the masses of about 100 of them, derive spin properties and overall shapes of more than 10,000 objects, yield much improved orbits and taxonomic classification for most of the observed sources. The final results will also include direct measurements of tiny radiative effects on small bodies, in particular of the Yarkovsky effect acting on near-Earth objects, and the measurement of tiny relativistic effects on the motion of some of these bodies. An impressive improvement of orbit accuracy for known objects will also become possible (by at least two orders of magnitude). Low activity distant comets and low elongation Earth crossers could also be discovered.

Given the above expectations, we organized a meeting aimed at informing the scientific community active in asteroid science about the unprecedented opportunities offered by the Gaia mission. The goal of this meeting was twofold: on one hand to spread information and awareness about Gaia; on the other hand, to organize future activities and collaboration, in order to best exploit the observations that Gaia will perform.

The workshop was supported by ESF through the GREAT network, and co-supported by the French “Actions Spécifique Gaia”, the University of Pisa and the Cassiopée Laboratory (Observatoire de la Côte d’Azur).

Scientific Organising Committee

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W. Thuillot

Local Organising Committee

A. Dell’Oro
P. Paolicchi
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Workshop organisation

The oral contributions were organised around the following axes:

- the Gaia mission. A few presentations focused on explaining the mission and its expected outcome to scientists that were not involved in Gaia up to now.
- Performance of Gaia on Solar System objects. The possibility of Gaia of determining asteroid sizes or discovering Near Earth Objects were analyzed. The problem of setting up a ground-based network for the follow up of asteroids discovered by Gaia was discussed.
- Orbit determination and improvement. Thanks to the capabilities of Gaia, a strong improvement of the accuracy of orbits for known asteroids will be possible. Also, specific mathematical problems exist for the determination of short-arc orbits of new asteroids. Contributions on the impact of Gaia orbital data on dynamical studies have been presented.
- Rotation and shape determination. Current studies involving the use of shape and spin properties of asteroids have been exposed. The future availability of Gaia data will be extremely important not only for statistical studies (given the large statistics) but also for the reduction of data coming from other surveys.
- Asteroid composition. The availability of asteroid spectro-photometry from the RP/BP instrument will provide an impressive amount of data for the study of dynamical families and of the collisional/dynamical life of the asteroid belt in general.
- Occultation observations. This activity will be strongly improved by the availability of precise orbits and stellar positions/proper motions, even from early and partial data releases. It will be of outstanding importance for the determination of the size of TNOs.
- Comets and Trans-Neptunian Objects. The capabilities of Gaia in this domain deserve further studies and are still unclear at present.
- Future organisation of activities in the frame of GREAT.

The whole workshop program is attached for details.

The workshop was held in the premises of the (Istituto Nazionale di Fisica Nucleare) University of Pisa. The location was perfect, with a large offer of hotels in the surroundings as well as restaurants and public transportations. An informal agreement with a hotel nearby allowed most participants to take profit of convenient fares.

Thanks to the funding by GREAT, no participation fees were requested, and lunches were offered to all the participants.

About half of 47 registered participants had never been involved in Gaia before, a considerable fraction implying a noticeable increase of awareness of the importance of Gaia for planetology. We sponsored the participation of young researchers and that of experts in the key areas addressed by the workshop.

A special issue of *Planetary and Space Science* will host the papers of the workshop.

General outcome

Several discussion opportunities were available during the workshop and they fruitfully involved all the participants around the main topics.

We identified several activities that can strongly benefit of the GREAT support, in different areas of Solar System research.

We also focused on few large issues, each addressing key aspects that are capable of fostering larger collaboration and activities:

Binary/multiple asteroids. These objects can offer a unique insight in the collisional and dynamical evolution. Gaia observations will be relevant for exploring them, either by examining the possible photocentre wobbling or directly detected companions. Specific studies concerning the performance of Gaia on binary objects are still largely unexplored. Our knowledge of binaries will strongly benefit from several ground-based observation techniques such as stellar occultations, interferometry, photometry, spectroscopy, adaptive optics imaging. Numerical approaches for simulating the birth and evolution of these objects are also part of this action.

Dynamical families Physical properties of asteroids are deeply related to their evolution. For example, rotational properties and shapes determine Yarkovsky evolution; spectra are related to the composition of the parent body and linked to meteorites reaching Earth; etc. Several aspects of asteroid formation and evolution can be addressed by using Gaia data.

These areas are wide domains of further exploration under different approaches: large observational projects, coordinated research, numerical modelling, etc.

More in general, the meeting was the first opportunity for gathering the planetology community around Gaia, well beyond the DPAC members. A high level of interest came from all over Europe. A few extra-EU participants were present.

A final agreement for coordinating further actions was reached, thus creating a favourable environment for evolving the GREAT work group on “Solar System science” toward further activities.

Final program

Wednesday, May 4

- 9:00 Reception of the participants at the conference site
- 9:35 Welcoming address by the authorities of the University of Pisa, the Dept. of Physics and the INFN
- 9:40 Communications from the LOC
- 9:50 F. Mignard – The Gaia mission

10:20 P. Tanga – The impact of Gaia on Solar System science
10:50 A. Dell’Oro – Observations of asteroids on the Gaia astrometric focal plane

11:10 *coffee break*

11:30 W. Thuillot – Ground-based follow up of asteroids observed by Gaia
11:50 D. Bancelin - Near Earth Asteroid astrometry with Gaia
12:10 Y. Krugly – Photometry and astrometry of asteroids in the frame of the ISON network
12:30 M. Todd – An optimal search strategy for Trojan asteroids and science follow-up of Gaia alerts with the Zadko telescope, Western Australia

13:00 *lunch*

14:30 K. Muinonen – Asteroid orbital inversion using Markov-chain Monte Carlo methods
15:00 D. Hestroffer – Global effects on asteroid dynamics
15:20 A. Fienga – Use of asteroids for the improvement of planetary ephemerides
15:40 H. Varvoglis - Constraining asteroid dynamical models using Gaia data

16:00 *coffee break*

16:20 B. Carry – Shape models and densities of asteroids in the post-Gaia era
16:40 F. Colas – Measuring asteroid densities

17:00-17:30 Discussion: Gaia mission, alerts, asteroid dynamics

Thursday, May 5

9:30 A. Cellino – Asteroid physical properties from Gaia
10:00 P. Pravec – Near-Earth and small main-belt binary asteroids, their population and properties
10:30 A. Carbognani - The representation of asteroid shapes: a test for the inversion of Gaia photometry
10:50 J. Hanus – The potential of combined sparse photometric data in asteroid shape modelling

11:10 *coffee break*

11:30 H. Campins - Colors of asteroid families
12:00 M. Delbo – Asteroid spectroscopy and unsupervised classification from Gaia data
12:20 J. Gayon-Markt – Mineralogical classification of asteroids before and after Gaia
12:40 F. DeMeo – Observations motivated by SDSS colors relevant to Gaia

13:00 *lunch*

14:30 M. Mueller – Age of asteroid surfaces from Gaia and WISE
14:50 P. Paolicchi – Spin vectors of asteroids: ideas and (needed) data
15:10 D. Oszkiewicz - Asteroid physical and dynamical properties from Lowell Observatory photometric database

- 15:30 J.E. Arlot - The astrometry of the natural planetary satellites applied to their dynamics before and after Gaia
- 15:50 K. Muinonen – Gaia Research for European Astronomy Training (GREAT)
- 16:10 *coffee break*
- 16:30 Discussion: physical studies. Organizing future activities in the frame of GREAT: propositions

Friday, May 6

- 9:30 M.W. Buie - Occultations and duplicity constraints on Gaia
- 10:00 B. Sicardy - Probing Trans-Neptunian Objects with stellar occultations
- 10:20 G. Tancredi - The size distribution of TNOs and the implications for the discovery of large members and the prediction of occultations
- 10:40 L. Beauvalet - Constraining Pluto's system with Gaia
- 11:00 *coffee break*
- 11:20 G.P. Tozzi - Observability of comets with Gaia
- 11:40 H. Rickman - Gaia and the new comets from the Oort cloud
- 12:00 – 12:45 - final discussion: occultations, comets. Future actions. Meeting summary.