EUROPEAN SCIENCE FOUNDATION

# Science Meeting – Scientific Report

**Scientific report (one single document in WORD or PDF file) should be submitted online <u>within two months of the event</u>. It should not exceed seven A4 pages.**

<u>*Proposal Title*</u>*: Asteroid Spectroscopy in Support of Gaia*

<u>*Application Reference N°*</u>*: 4405*

1)      Summary (up to one page)

The workshop was held at "La maison du Séminaire" hotel in Nice, France, on June 6 & 7, 2013, and hosted by the Observatoire de la Côte d'Azur. This workshop was sponsored by the European Science Foundation's GREAT program, the Laboratoire Lagrange of the Observatoire de la Côte d'Azur, the Action Specifique Gaia, and the University of Central Florida.

The workshop web page: <u>http://assg2013.sciencesconf.org/</u>

The aim of this workshop was to implement a coordinated four-year program of ground- based asteroid spectroscopy in support of Gaia's asteroid observations. The Gaia mission will produce a dramatic increase in the number and quality of asteroid spectra in the 0.35 to 0.9 micron wavelength range thanks to the BP and RP spectrophotometers on board of the mission (Delbo et al., 2012). Observations at other wavelengths, particularly in the near-infrared (1 - 4 microns), will enhance significantly the diagnostic value of the Gaia asteroid observations. A combination of visible and infrared spectra can determine asteroid surface mineralogy; in turn this information is used to constrain models of the origin and evolution of asteroids, of our solar system, and of the origin of Earth's water (e.g., Campins et al. 2010).

The workshop was attended by 37 researchers from Europe, USA, Ukraine and Brasil. Substantial funds were devoted to cover the travel and lodging expenses of young researchers, post-doc and Ph.D. students. We also waived registration fees.

The presentations at the workshop were of very high scientific quality and covered a wide range of topics, from spectroscopy of asteroids and other minor bodies from the ground and space to laboratory work. The latter was shown to be of fundamental importance for the interpretation of the astronomical observations in terms of mineralogy and composition of asteroids and for the search of their meteorite analogs.

The scientific presentations, discussions and round table mainly focused on the access of Gaia asteroid spectroscopy to the general community and on some scientific topics for which the combination of Gaia data with ground based infrared data are expected to provide breakthroughs in the field. For instance, there are hints that Gaia asteroid magnitudes combined with BP-RP data and complementary near-IR spectra and with the 3 microns NASA WISE photometry (now available on the internet) can provide detection of the long-searched water/hydration bands in the Trojans of Jupiter (talk by PhD student V. Ali-Lagoa); Gaia asteroid magnitudes combined with BP-RP data and with complementary near-IR spectra can distinguish asteroids of overlapping primitive carbonaceous families in the inner asteroid belt (talk by K Walsh), which cannot be separated on the basis of the visible spectrum (talk by N. Pinilla-Alonso) or by their albedo (talk by H. Campins and M. Delbo); Gaia data will be fundamental for the identification of asteroid families.

Needless to say, the workshop was a success and it allowed new collaborations to be established and existing ones to be reinforced. Furthermore, this workshop raised the visibility of the planetary science group of the observatories de la cote d'Azur, that is in charge of the extraction and classification of asteroid spectroscopic data from Gaia, within the larger world-wide community.


2) Description of the scientific content of and discussions at the event (up to four pages)

The participation of researchers from a large and world-wide community of asteroid spectroscopists allowed discussions on topics at forefront of solar system research (see below). Also, the presence of key scientists involved in the Gaia Data Processing and Analysis Consortium DPAC such as A. Brown, C. Jordi, and P. Tanga, on one hand, allowed scientists outside the DPAC to gain a deeper understanding of Gaia data products and release policy and, on the other hand triggered discussions on how the DPAC could optimise the output and the release of Gaia solar system data in order to have the most outstanding impact on asteroid research.

Below is summary of the main scientific topics and discussions at the event:

The community was very interested in early releases of asteroid magnitudes and spectra of Gaia. What would be most important asteroids for which an early data release could produce a breakthrough ? Near-Earth Asteroids and asteroids of primitive, inner main belt families were two possible suggestions.

It was shown how the combination of Gaia data with ground based spectroscopy in the near infrared and photometry in the 3.5 micron region obtained by the NASA WISE space telescope could potentially lead to the detection of the hydration bands in the spectra of Jupiter Trojans. While these bands are theoretically expected, their detection has always escaped from telescopic search.

The origin and the nature of the so-called M-type asteroids was another topic of debate. While it is clear that only a few of these asteroids are the metallic cores of differentiated asteroids, exposed to space by impacts, the mineralogical nature of most of M-type asteroid eludes careful scrutiny from ground based spectroscopy. Are these asteroids metallic ? and to what extent ? Are they the progenitors of complex carbonaceous meteorites such as the CB meteorites ?

The origin of carbonaceous near-Earth objects, their relation to carbonaceous meteorites and the delivery of organic, carbon-rich compounds to Earth was a matter of presentations and debate at the workshop. The selection of sample-return space missions such as the NASA OSIRIS-REx (two Cols of the mission attended the conference) and JAXA HAYABUSA II, targeting carbonaceous asteroids, as well as the recent discovery of new asteroid families in the inner main belt has brought new life to the topic. Gaia accurate magnitudes and spectra of carbonaceous asteroids will vastly improve the statistic on the physical information that we have of these bodies. The combination of Gaia spectra with ground based near-infrared spectra is crucial: it has been shown at the conference that, while carbonaceous asteroids show diversity mainly in the near-infrared spectrum, thy can have similar visible spectra and albedos.

Accurate Gaia photometry, coupled with a model describing how light vary with the angle between the Sun, the asteroid, and the observer, is also a key to improve asteroid albedos through a re-analysis of all available thermal infrared observations of solar system minor bodies.

A key discussion was about the choice of which asteroids should have highest priority for near-infrared spectroscopy during the Gaia mission. For example, it was shown that B-type asteroids will be particularly interesting targets for infrared spectroscopy; this is because they have similar spectra in the visible region but dramatically different near-infrared spectra. So, decision was made to target B-type asteroid early in our 4-year campaign.

3) Assessment of the results and impact of the event on the future directions of the field (up to two pages)

The major impacts of the meeting in the field of asteroid spectroscopy are:

(a) to make aware the asteroid spectroscopy community outside the DPAC of the Gaia low-resolution BP-RP spectra of solar system minor bodies in the visible. This is very important as Gaia is expected to obtain visible spectra for a large sample of asteroids down to magnitude V~19-20 (see Delbo et al., 2012). The community is thus now focusing on spectroscopic observations complementary to the ones that Gaia will obtain, e.g. in the near-infrared;

(b) given the nature of BP-RP spectra, which will be obtained without the use of a slit, there is an urgent need of the verification/validation of the data produced by Gaia. An important help of the community in this respect will be the observation in the same wavelengths of control asteroids possibly of great scientific interests (as the carbonaceous primitive spectroscopic types B and C) under the observing conditions that Gaia will encounter;

(c) it is known that members of asteroids families have similar orbits and are the remnants of large, collisionally-disrupted asteroids (e.g., Cellino et al. 2002). The Themis family, for instance, is one of the most numerous families in the asteroid belt. Asteroid 24 Themis is the largest member of this family, which formed more than 1.0 Gyr ago (Nesvorn" et al. 2008). This family is of interest for several reasons, including that it could have contributed to the origin of water and organic molecules on Earth (e.g., Campins et al. 2010). In addition, two small members of this family are also known as 'main belt comets' (MBCs) because they sometimes show dust tails. The detection of water-ice and organic molecules on the surface of 24 Themis (by two independent groups using near-infrared spectroscopy Campins et al. 2010, Rivkin and Emery 2010)

is consistent with ice sublimation as the mechanism that drives the "cometary" activity in these MBCs. One interesting lingering question is: why are some Themis family asteroids active and not others? A factor that may help explain why only a few Themis family members show cometary activity is a heterogeneous set of compositions among small Themis fragments. Any possible compositional heterogeneity among Themis-family asteroids will be tested and investigated in greater detail by a combination of the Gaia and ground-based observations we propose in our campaign of asteroid spectroscopy;

(d) a new method for the identification of the member of asteroid families was developed by Walsh and Delbo in the last years (see talk by Walsh and Delbo). This method makes use of physical information of asteroids such as their albedo, color or spectrum and of the size dependent spreading of family members. As Gaia will provide spectra of more than 100,000 asteroids, these data will be of fundamental importance for family members identification. A proposal for an early release of BP-RP data of some asteroid family members has been discussed;

4)      Annexes 4a) and 4b): Programme of the meeting and full list of speakers and participants

**Annex 4a: Programme of the meeting**

**Thursday June 6**

9:00 AM Welcome, Introductions and Announcements
9:30 Introduction to Gaia Mission: Brown, A., & Jordi, C.
10:00 Invited Talk. Gaia as an observatory of the Solar System: Tanga, P.
10:30 Invited Talk. The importance of Gaia BP/RP for asteroid science: Cellino, et al.

**11:00 Coffee Break**

11:20 Invited Talk. Asteroid spectrophotometry in the visible from Gaia: Delbo, et al.
11:50 Invited Talk. Taxonomy distribution of asteroids from SDSS photometry: Carry, B., & DeMeo, F.
12:20 Contributed Talk. Aqueous alteration on minor bodies of the Solar System: Fornasier, et al.
12:35 Contributed Talk. X-complex asteroids: results from the groundbased spectroscopic surveys: Fornasier, S.
12:50 Contributed Talk. Asteroid composition types and albedos: complementary data from photometry and polarimetry: Belskaya, I.

**13:05 Lunch Break**

14:30 Invited Talk. "Space weathering" laboratory experiments in support of spectroscopic studies of asteroids: Brunetto, R.
15:00 Contributed Talk. Reflectance properties of primitive asteroids and chondrites: Moyano-Cambero, C., & Trigo-Rodríguez, J.
15:15 Contributed Talk. Spectroscopy and Photometry of Meteorites in Support of GAIA: Beck, et al.
15:30 Invited Talk. Spectroscopy of primitive asteroids from ground-based telescopes in support of the Gaia mission: de Leon, et al.

**16:00 Contributed Talk. Combining WISE data and visible-to-near-infrared spectra of primitive asteroids: Ali-Lagoa, et al.**

**16:15 Coffee Break**

**16:30 Contributed Talk. A New Interpretation of the Surface Composition of Asteroid Bennu (1999 RQ36): Anhydrous Minerals Similar to CV Chondrites? Campins, et al.**
**16:45 Contributed Talk. Near-Infrared Spectroscopy of asteroids in the Polana's family: Pinilla-Alonso, et al.**
**17:00 Contributed Talk. Spectroscopy of Primitive Inner-Belt Asteroids: Landsman, et al.**
**17:15 Contributed Talk. Exploring asteroid families by combining multi-wavelength data: Walsh, K., & Delbo, M.**
**17:30 Contributed Talk. The Origin of Asteroid 162173 (1999 JU3): Comfort, et al.**
**17:45 Contributed Talk. Physical Characterization of Warm Spitzer Observed Near-Earth Objects: Thomas, et al.**

**18:00 Adjourn**
**Group Dinner (paid individually)**


**Fri. June 7**

**9:30 AM Invited Talk. Compositions of primitive asteroids: Constraints from 2 – 4 µm spectroscopy: Emery, J.**
**10:00 Invited Talk. Asteroid spectroscopy in the Mid Infrared: Vernazza, P.**
**10:30 Invited Talk. Laboratory Thermal Emission Spectroscopy and Goniometry in a simulated space environment: Bowles, et al.**

**11:00 Coffee Break**

**11:20 Contributed Talk. Investigation of the 10 µm Emission Feature: Hargrove, et al.**
**11:35 Contributed Talk. The study of asteroids in cometary orbits using surveys and missions: Licandro**
**11:50 Contributed Talk. Gaia — distinguishing active comets from inactive asteroids: how will its performance be?: Gafeira, et al.**
**12:05 Contributed talk. A dedicated telescope for asteroid studies in Brazil: Lazzaro, et al.**
**12:20 Contributed Talk. Mapping the early distribution of volatiles in the Main Belt with the JPAS/J-PLUS photometric survey: Carvano, J.**
**12:35 Contributed Talk. Selecting asteroids for a spectroscopic survey: Oszkiewicz, et al.**

**12:50 Lunch Break**

**14:30 Contributed Talk. Asteroid spectroscopy with SALT: a feasibility study: Kwiatkowski, T.,**
**& Oszkiewicz D.**
**14:45 Contributed Talk. Photometry and Astrometry of Gaia's Targets Using the ISON Telescopes: Krugly et al.**

**15:00 Round Table: Ground Based Support for Gaia. Moderator: P. Tanga**

**16:15 Coffee Break**

**16:35 Round table: Primitive Asteroids. Moderator: M. Delbo**

**17:35 Adjourn**

**Annex 4b: Full list of speakers and participants**

**List of Speakers**

| name | City, Country |
|------|---------------|
| Mr. Victor Ali-lagoa | La Laguna, (ES) |
| Dr. Pierre Beck | Grenoble, (FR) |
| Dr. Irina Belskaya | Kharkiv, (UA) |
| Dr. Neil Bowles | Oxford, (UK) |
| Dr. Antony Brown | Leiden, (NL) |
| Dr. Rosario Brunetto | Orsay, (FR) |
| Prof. Humberto Campins | Orlando, Florida, (US) |
| Dr. Benoit Carry | Paris, (FR) |
| Dr. Jorge Carvano | Rio de Janeiro, (BR) |
| Prof. Alberto Cellino | Pino Torinese, (IT) |
| Ms. Christine Comfort | Orlando, Florida, (US) |
| Prof. Hestroffer Daniel | Paris, (FR) |
| Dr. Marco Delbo | Nice - Cedex 4, (FR) |
| Dr. Rene Duffard | Granada, (ES) |
| Dr. Josef Durech | Praha 8, (CZ) |
| Prof. Joshua Emery | Knoxville, (US) |
| Dr. Sonia Fornasier | Meudon Paris, (FR) |
| Ms. Kelsey Hargrove | Orlando, Florida, (US) |
| Prof. Carme Jordi | Barcelona, (ES) |
| Dr. Yurij Krugly | Kharkiv, (UA) |
| Dr. Tomasz Kwiatkowski | Poznan, (PL) |
| Ms. Zoe Landsman | Orlando, Florida, (US) |
| Dr. Daniela Lazzaro | Rio de Janeiro, (BR) |
| Dr. Javier Licandro | La Laguna, (ES) |
| Dr. Tadeusz Michalowski | Poznan, (PL) |
| Mr. Carles Moyano-Cambero | Bellaterra, Barcelona, (ES) |
| Dr. Dagmara Oszkiewicz | Poznan, (PL) |
| Dr. Nuno Peixinho | Coimbra, (PT) |
| Dr. Noemi Pinilla-Alonso | Knoxville, (US) |
| Dr. Paolo Tanga | Nice - Cedex 4, (FR) |
| Dr. Cristina Thomas | Flagstaff, (US) |
| Dr. Pierre Vernazza | Marseille Cedex 13, (FR) |
| Dr. Kevin Walsh | Boulder  Colorado, (US) |

**List of Participants**

| name | City, Country |
|---|---|
| Dr. Kryszczyńska Agnieszka | Poznan, (PL) |
| Mr. Victor Ali-lagoa | La Laguna, (ES) |
| Dr. Pierre Beck | Grenoble, (FR) |
| Dr. Irina Belskaya | Kharkiv, (UA) |
| Professor Philippe Bendjoya | Nice - Cedex 4, (FR) |
| Ms. Alexandra Betrone-Harpst | Orlando, Florida, (US) |
| Dr. Neil Bowles | Oxford, (UK) |
| Dr. Antony Brown | Leiden, (NL) |
| Sir Rosario Brunetto | Orsay, (FR) |
| Professor Humberto Campins | Orlando, Florida, (US) |
| Dr. Benoit Carry | Paris, (FR) |
| Dr. Jorge Carvano | Rio de Janeiro, (BR) |
| Professor Alberto Cellino | Pino Torinese, (IT) |
| Ms. Christine Comfort | Orlando, Florida, (US) |
| Professor Hestroffer | Daniel  Paris, (FR) |
| Dr. Marco Delbo | Nice - Cedex 4, (FR) |
| Dr. Rene Duffard | Granada, (ES) |
| Dr. Josef Durech | Praha 8, (CZ) |
| Professor Joshua Emery | Knoxville, (US) |
| Dr. Sonia Fornasier | Meudon Paris, (FR) |
| Dr. Laurent Galluccio | Nice - Cedex 4, (FR) |
| Ms. Kelsey Hargrove | Orlando, Florida, (US) |
| Professor Carme Jordi | Barcelona, (ES) |
| Dr. Yurij Krugly | Kharkiv, (UA) |
| Dr. Tomasz Kwiatkowski | Poznan, (PL) |
| Ms. Zoe Landsman | Orlando, Florida, (US) |
| Dr. Daniela Lazzaro | Rio de Janeiro, (BR) |
| Dr. Javier Licandro | La Laguna, (ES) |
| Professor Tadeusz Michalowski | Poznan, (PL) |
| Mr. Carles Moyano-Cambero | Bellaterra, Barcelona, (ES) |
| Dr. Dagmara Oszkiewicz | Poznan, (PL) |
| Dr. Nuno Peixinho | Coimbra, (PT) |
| Dr. Noemi Pinilla-Alonso | Knoxville, (US) |
| Dr. Paolo Tanga | Nice - Cedex 4, (FR) |
| Dr. Cristina Thomas | Flagstaff, (US) |
| Dr. Pierre Vernazza | Marseille Cedex 13, (FR) |
| Dr. Kevin Walsh | Boulder, Colorado , (US) |