

TWO YEARS OF CNRS-INSU 'ACTION SPÉCIFIQUE' GAIA

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Résumé. The 'Action Spécifique' Gaia (AS Gaia) has been created by the French National Institute for the Sciences of the Universe with the aim of enhancing the scientific return from the European Space Agency (ESA) Gaia mission, due to be launched during Spring 2012. The various actions taken during the last two years are presented here.

1 Introduction

Space Astrometry is a branch of space science where French scientists, Space Agency (CNES) and space industry have been deeply involved from the very beginning (ESA's Hipparcos was built from an original idea of Pierre Lacroute, the then Director of the Strasbourg Observatory). Building on the success of the Hipparcos mission, Gaia was proposed to ESA in 1993 (Lindegren & Perryman, 1996) within the frame of ESA's *Horizon 2000 Plus* long-term scientific programme. It was included in the ESA's Science Programme in 2000 and is due to be launched in Spring 2012. Many French astronomers contributed, in straight collaboration with other European colleagues, to establish the Gaia science case, to define the specification of the astrometric, photometric and spectroscopic instruments of Gaia. The DPAC (Gaia Data Processing and Analysis Consortium) is chaired by François Mignard (Observatoire de la Côte d'Azur) and France is the first contributor to the Consortium (about 25 % of the members). Accordingly, the creation of an 'Action Spécifique' was proposed (Turon et al., 2007) to the CNRS National Institute for the Sciences of the Universe (INSU) and created in August 2007, for four years.

The challenge for AS Gaia is to prepare the French astronomers to be in a position to best exploit the Gaia scientific data in their quantity and diversity, and in their various domains of application. Its role is therefore to suggest and support actions in order to fulfil the needs in modelling and theoretical developments and on the complementary and follow-up observations that should be organised before, during and after Gaia operations. AS Gaia has also been requested by INSU to support the ground-based observations required by the Gaia data analysis and not otherwise funded.

Finally, AS Gaia is the voice of the French Gaia community towards our National funding authorities, and as such its chair attends CNES and INSU astronomy working meetings, contributes to the establishment of the INSU roadmap by producing documents and attending the various meetings, and supports the requests for funding or permanent positions.

2 Actions of the last two years

With a global funding of 30 k€ per year (15 k€ in 2007), AS Gaia opened three announcements of opportunity (end 2007, 2008 and 2009). The main broad lines of funding are the following :

- Ground-based observations required by the Gaia data analysis and not otherwise financed ;
- Organisation of topical workshops ;
- Modelling of the various objects which will be observed by Gaia : stars (interiors and atmospheres) ; the Galaxy ; Solar System objects ; galaxies ; compact objects (especially QSOs) ;
- Support to European and, more generally, international collaborations ;
- Support young astronomers attendance to international meetings ;
- Support to public outreach and conferences by the production of Gaia documentation in French.

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2.1 *Ground-based observations in support to Gaia data analysis*

A number of ground-based observations are required to support the Gaia data analysis and a special group, GBOG, chaired by Caroline Soubiran, has been created within DPAC to co-ordinate these (Soubiran et al. 2008). AS Gaia contributed to the funding of various actions :

- Observation of radial velocity standard stars for the initial calibration of the spectrograph on board Gaia, the Radial Velocity Spectrograph (RVS) : observations performed with the Coralie spectrograph, operated by the Geneva Observatory in La Silla. The observations performed in France with the Sophie (Observatoire de Haute Provence) and Narval (Observatoire du Pic de Midi de Bigorre) spectrographs are funded by other national funding. See Crifo et al. (2009).
- Spectroscopic observations of minor planets to calibrate and test the performance of classification algorithms.
- Astrometric observations of WMAP, a test of the performance of such observations to accurately reconstruct the orbit of the satellite, as is planned to be done for Gaia.
- Support to the realisation of a pipeline for processing the Narval spectra.
- Support to the setting of a network of ground-based observations of Solar System minor bodies, especially near-Earth objects.

2.2 *Meetings and workshops*

After a kick-off meeting in December 2007, an annual meeting of AS Gaia is now hosted as a parallel session during the ‘Journées de la SF2A’, which is thanked here. All presentations and papers are available from the AS Gaia web site at wwwhip.obspm.fr/gaia/AS.

In addition to these annual plenary meetings, a number of topical workshops have been or are being organised :

- “**Reference systems and QSOs**”, organised at Bordeaux Observatory by P. Charlot and G. Bourda, 24 October 2008. The main topics were : settling of the Gaia reference frame ; study of the long-term and short-term variations of the photocentres of AGNs and of potential discrepancies between optical and VLBI positions ; link of ICRF to the Gaia frame (Bourda & Charlot, this meeting).
- “**Earth-based support to Gaia Solar System science**”, organised in Beaulieu sur Mer by P. Tanga and W. Thuillot, 27-28 October 2008. The main goals were to plan for ground-based observations which would complement Gaia observations (for example to enlarge the period of observation over the orbits of solar system objects, to plan for detailed spectroscopic observations, etc.) ; to identify new techniques which would become possible thanks to the unprecedented accuracy of Gaia positions and proper motions ; to organise a network of ground-based observers (Thuillot & Tanga, this meeting).
- “**Multiplex spectroscopy in complement to Gaia**”, organised at Nice Observatory by A. Recio-Blanco and V. Hill, 19-20 February 2009, in preparation to the March 2009 ESO workshop ‘Spectroscopic Survey Workshop’. The goal was to anticipate the requirements in ground-based spectroscopy in complement to the Gaia data in the domain of Galactic Archeology : radial velocity and chemical abundances for stars not observed by the Gaia RVS or not observed in enough detail (Bienaymé et al., this meeting).
- “**The Milky Way**”, organised at the Besançon Observatory by A. Robin, C. Reylé and M. Shulzeis, 5-6 November 2009. The meeting will be devoted to the various methods used to test the models of formation and evolution of galaxies, in the context of Gaia.
- “**Gaia et la physique des AGNs**”, organised at Nice Observatory by E. Slezak, is planned for early 2010. The AGNs Gaia catalogue will be much larger and much more homogeneous than ever obtained earlier. The aim of the meeting is to initiate the work on the impact of these data over the understanding of the physics of these objects.

These workshops have a high priority in the annual announcements of opportunity and proved to be very efficient to co-ordinate the work of various teams within France and to open the way to new national and international collaborations. We plan to organise other such workshops in the coming years.

2.3 Modelling for Gaia data analysis

Gaia will observe all objects down to magnitude $V = 20$, i.e. a very large variety of stars, Solar System bodies and compact extragalactic objects. To be able to identify, classify and characterise them, it is essential to have good models of these objects as seen by the Gaia instrument. With one billion objects observed, any category of objects will include a huge number of elements and the classification algorithms have to be carefully tested in advance. A number of such actions have been supported by AS Gaia these two last years :

- Improvement of the modelling of massive stars with emission lines. Test and improvement of the classification algorithms.
- Simulation of multiple stellar systems.
- Development of library of synthetic spectra of galaxies to be used for the automatic classification of galaxies unresolved by Gaia observations.
- Simulation of a catalogue of quasars and AGN, and test of its observation with Gaia.
- Simulation of the detection and observation of binary minor planets.
- Simulation of the observation of extended objects.

2.4 Modelling for Gaia data scientific exploitation

Gaia has the discovery potential of a survey which will provide data of unprecedented accuracy, of unprecedented quantity, and for high variety of objects, running from Solar System bodies to unresolved galaxies, through all spectral types and evolutionary stages, even the rarest or the fastest. As a result, the scientific exploitation of such data have to be carefully prepared in advance. In this respect, various works have been supported by AS Gaia :

- Kinematic and dynamical modelling of the galactic bulge ;
- 3D and NLTE modelling of stellar atmospheres, aiming at the improvement of the determination of atmospheric parameters and abundances ;
- Modelling of the various types of emission-line stars and search for criteria to identify each of them from the Gaia spectroscopic and photometric observations ;
- Development of an algorithm and software to predict close encounters between minor planets, with the aim of mass determination ;
- Development of criteria for the taxonomic classification and absolute magnitude determination of minor planets observed with Gaia ;
- Determination of the conditions of observation of comets with Gaia, modelling of the non-gravitational forces perturbing their orbits.

2.5 Communication

A few steps have been taken to help the development of communication in France about the project and produce documentation for conferences and exhibitions : edition of posters and folders, and translation of ESA’s documentation, about the various aspects of the Gaia mission and science, more generally about astrometry and its evolution across centuries ; funding of models of the satellite ; development of a section of the AS Gaia web site dedicated to documentation in French about astrometry, Hipparcos and Gaia.

3 Preparing for the future

AS Gaia, through its Scientific Committee, actively contributed to the preparation of the astronomy roadmap prepared by INSU during 2009 and produced several documents :

- a document about the permanent research positions that would be required to take full benefit of the French involvement in the Gaia data processing and analysis and its major contribution to the DPAC Consortium ;
- a document about ‘observation services’ (which constitute one part of the mandatory activities of scientists with a position of ‘astronomer’ in France).
- a document about ground-based observations, and relevant instrumentation and telescopes that would be needed to complement Gaia observations ;

- a special document dedicated to the complementary spectroscopic observations that would be essential in complement to Gaia measurements in the domain of Galactic astronomy, and to the relevant instrumentation (multiplex spectrograph on a wide field telescope), proposing several possible solutions ;
- a contribution to the document produced for the INSU roadmap by the ‘Programme National de Cosmologie et Galaxies’ ;
- a contribution to the document produced for the INSU roadmap for ‘space-ground-based coordination’
- contributions to the ASTRONET forum about the use of 2-4 m telescopes.

All these actions have to be developed and enhanced in the coming years in straight co-operation both within France with the various ‘Programmes Nationaux’ and with the European colleagues and networks (ELSA, RTN on European Leadership in Space Astrometry ; GREAT, an ESF network ; and any further network proposal to the European Commission). In particular, the series of topical workshops should be continued, and initiatives related to modelling and ground-based observations will also be strongly supported. A special effort has still to be done about scientific communication and further preparation of documentation and of presentation material.

The Gaia data will give a major input to various fields of astronomy and astrophysics where the French scientists are involved, and it is essential that all steps are taken so that they are fully aware of the characteristics of these data, in accuracy, sky and magnitude coverage, and that they are fully prepared to fully exploit this unique opportunity.

The Scientific Committee of AS Gaia for the years 2007-2010 is composed of Catherine Turon (chair), Frédéric Arenou (substitute to C. Turon in national meetings), Olivier Bienaymé, Daniel Hestroffer, Vanessa Hill (link with Programme National Cosmologie et Galaxies, PNCG), François Mignard (Chair of DPAC), Bertrand Plez (link with Programme National de Physique Stellaire, PNPS), Annie Robin (link with PNCG), Caroline Soubiran (member of the Gaia Science Team), Frédéric Thévenin (link with PNPS). The AS Gaia may be contacted at AS.Gaia@obspm.fr or through its web site wwwhip.obspm.fr/gaia/AS.

Références

- Bienaymé, O., et al., 2009, Multiobject spectroscopy as a complement for Gaia, this volume
- Bourda, G., Charlot, P., 2009, Celestial Reference Frames in the Gaia era, this volume
- Crifo, C., Jasniewicz, G., Soubiran, C., et al., 2009, The Gaia-RVS standards : a new full-sky list of 1420 stars with reliable radial velocities
- Lindgren, L., & Perryman, M.A.C., 1996, *A & A Suppl.*, 116, 579
- Soubiran C., Allende Prieto, C. ; Altmann, M., et al., 2008, SF2A-2008 : Proceedings of the Annual meeting of the French Society of Astronomy and Astrophysics, C. Charbonnel, F. Combes and R. Samadi eds. Available on AS Gaia site
- Thuillot, W., Tanga, P., 2009, this volume
- Turon, C., Mignard, F., Arenou, F., 2007, Proposition pour une Action Spécifique Gaia