Research Networking Programmes

Science Meeting – Scientific Report

The scientific report (WORD or PDF file - maximum of seven A4 pages) should be submitted online within two months of the event. It will be published on the ESF website.

***Proposal Title**: Gagnes (Gaia for AGNs and Extragalactic Science)*

***Application Reference N°**: 5602*

1) Summary (up to one page)

The Gaia satellite is presently collecting over the whole sky and with an exceptional accuracy quasars as well as bright and compact AGNs on the deepest z-coverage. In order to prepare properly the analysis of the output data from this mission, we decided to organize the GAGNES meeting (Gaia for AGN and Extragalactic Science) hold at the Institut d'Astrophysique de Paris on July, 8-9-10, 2015. This meeting gathered 37 participants, including members of the Gaia-DPAC and members of international institutes and observatories (USNO, JPL-NASA, Danmark, Germany, Belgium, Portugal, Austria, Brasil and France / Nice, Bordeaux, Paris.

In the continuity of the four successful EGSG (ExtraGalactic Science with Gaia) meetings already organized in the recent years at the Institut d'Astrophysique de Paris, Observatoire de Paris and Observatoire de La Côte d'Azur, GAGNES concerned two main scientific communities, respectively Astrophysicists and Reference Systems experts, who presented their recent developments with the aim of carrying out efficiently the analysis and interpretation of the upcoming Gaia data on AGNs. Three sessions were proposed, all followed by very fruitful discussions and conclusions, to define the perspectives on extragalactic and AGN science in the view of the publications of data related to Gaia.

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

In the following we summarize the three sessions organized in the frame of the GAGNES meeting :

- **Session I** (3 invited reviews + 7 contributions) was on **The Galactic Center, the AGN/host relation and compact galaxies.**

Gaia is very useful to observe very good astrometric standards required for estimating mass, distance and intrinsic motion of such sources as SgrA in the Galactic Center. Due to confusion and obscuration, the direct insight of the Galactic Center is improbable. Nevertheless the study of our Galactic center (GC) with very modern experiments such as GRAVITY at the VLT is fundamental to understand the behaviour of black holes at the center of galaxies in general. In this aim a review of the knowledge concerning the GC was done, including a very precise determination of the mass of the central black hole from the relativistic motion of surrounding stars.

Compared to VLBI, Gaia will be able to provide a very precise astrometric position of quasar cores at optical bandwidths while VLBI, of similar microarscecond resolution generally identifies the AGN jets. The identification with Gaia of Binary Black Holes favored by VLBI observations of compact sources was actively discussed.

The GAIA photometric and spectroscopic monitoring as well as upward and downward alerts will help the HE/VHE source detection. The present status of the Gaia-ESO survey (www.gaia-eso.eu) adding the spectrometric information to Gaia surveys was presented to accompany the role of Gaia for helping to build the interstellar extinction maps, mainly in the Milky Way.

Mass estimates of supermassive black holes are possible with Gaia photometers (and not RVS), but need template modeling and extensive simulations to quantify uncertainties: line dispersion is potentially the better width measure. Gain in accuracy is expected by a factor ~6 or more. The impact of the future e-MERLIN and SKA telescopes was also mentioned. Concerning the relation of black hole masss with galaxy host properties (bulge mass, velocity dispersions and others) the respective emissions of star, dust and AGN torus with scattering will be disentangled from the continuous optical to far-infrared spectral energy distributions SEDs with the code Pegase. Simulated through the BP/RP Gaia filters, that will clarify the identifications of sources detected by Gaia. The case of dwarf galaxies which will be detected with Gaia is considered and interpreted in terms of galaxy evolution.

Session II (3 invited reviews + 6 contributions) p**resented reviews on the Gaia state-of-the art and specific data processing.**

This includes extragalactic results, data processing and models. The main BP/RP results are presented while the RVS is confirmed to be limited to stars and interstellar medium. Preliminary results on QSOs observations in relation with the statistics of the ICRF sources, including double or multi-imaged sources, was presented. Good results are obtained on 2700 sources at ~ 30 mas precision, whereas 700 sources remained undetected.

For the overall compilation catalog of quasars LQAC, statistics on QSOs to G=20.7 show that 12% of known QSO's will not be detected by Gaia. The detection and the chains of data processing for extended Extra Galactic objects (Galaxies and Quasars) sources including the specific case of lensed galaxies, were specifically considered

and are in active developments. The determination of QSO's redshifts from a PCA method was also proposed.

The complementary objectives of Gaia with the GRAVITY instrument are presented. GRAVITY is the NIR interferometric imager for an imaging @ 1 mas and astrometry @ 10 mas, applied in particular to Active Galactic Nuclei to probe the central 100pc at any redshift.

- **Session III** (2 invited reviews + 8 contributions) focused on **Astrometric catalogs and Reference systems.**

The construction of VLBI-radio ICRF-2 and the construction of the next ICRF3 were presented for a significant comparison with the future optical Gaia celestial reference frame, named as GCRF. Multi-wavelength activities are proposed for the astrometric and radio-optical link. The advantages are not only for reference systems but also to probe AGN geometry and physics. To find more transfer sources for building the ICRF catalogs, a project of VLBI astrometric positions is associated to EVN and VLBA observations on 119 point-like sources (BVID catalog). The LQAC presentation as an improved astrometric quasar catalog associated to the complete bank of ICRF QSOs, in relation with VLBA calibration, was detailed and discussed.

The science with quasars brings fundamental bases to build reference systems as well as to link supermassive black holes and star formation histories at the earliest epochs. The GAGNES meeting concerns a large community of scientific researchers and engineers involved and/or interested by Gaia data (analysis, mining, physics). On the other hand, the GAGNES meeting will gather the widest community on various topics for the science exploitation and complementary programs. The Gagnes meeting was mainly funded by the program GREAT: Gaia Research for European Astronomy Training. The first phase is now closed, a presentation of the new phase has also been presented at the end of the meeting to pursue the multiple collaborations initiated by GAGNES and the EGSG meetings.

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

The two communities (astrophysicists and reference systems experts) have the common objective to support the alignment/incorporation of Gaia reference frame in accordance with the fundamental reference frame ICRF2 and its extension.

Gaia can also detect detailed physics of AGNs and constrain the accretion regime, time evolution of disks and torus at the center of AGN's. In particular photometric and photocentric variability of AGN due to the physics of the accretion in radio quiet AGN (just a few seen at HE) will be analyzed.

Another program is based on developments of the extented objects with Gaia. Galaxies, starbursts or AGN required a specific attention for morphological and astrometric analyses. Joined to spectroscopic templates and emission lines, building of synthetic AGN+galaxies spectroscopy and colors is a priority for the two communities.

Future meetings will be needed to a better interpretation of Gaia data (analysis, mining, physics) when the first set of data will be delivered. As for this meeting GAGNES, the help of the program GREAT: Gaia Research for European Astronomy Training will be welcome.

4) Annexes 4a) Programme of the meeting and

Program -version 2

Wednesday July 8th

1. Galaxy Center, AGN/host galaxy relation, compact galaxies

9h-9h30 Welcome & registration (free, for lunches at IAP), Hall entrance, Institut Astrophysique de Paris

9h30 - 10h15 : Review : The power of astrometry in the Galactic center S. Gillessen (MPE)

10h15 – 10h45 : Structure of compact radio sources and the link with Gaia J. Roland (IAP)

10h45-11h15 Coffee-break

11h15 -11h 45 : The Gaia-ESO Survey and the interstellar extinction M. Schultheis (OCA)

11h45 -12h15 : High energy radiations (Galactic center and nearby AGNs) H. Sol (Obs. Paris-Meudon)

12h15- 12h30 : Discussion on the Galactic Center

12h30-14h Lunch*(IAP)*

14h-14h45: Review: Black hole mass determination with Gaia M. Vestergaard (Niels Bohr Institute and University of Arizona, USA)14h45-15h15 : Methods of selection of quasars I. Pâris (Trieste Obs)

15h15-15h45 : Chasing off-center AGNs with Gaia S. Anton (IASS, Lisbone)

15h45 - 16h15 Coffee break

16h15-16h45 : Star formation and black hole masses with Gaia B. Rocca-Volmerange (Institut d'Astrophysique de Paris) 16h45-17h00 : Gaia and dwarf compact galaxies E. Livanou (Univ.Athens)

17h00-17h30 : Discussion on AGN and star formation

Thursday July 9th

2. The satellite Gaia: Present Status

9h30- 10h15: Review: Gaia state-of-the art and the main BP/RP results T. Prusti (ESA)

10h15-11h00 : Review: A first glimpse at Gaia observations of quasars F. Mignard (OCA)

11h00-11h30 Coffee-break

11h30-12h00 : Processing of Extragalactic Sources inside Gaia DPAC L. Galluccio (OCA)

12h00-12h30 : Lensed QSO detection using Gaia: DPAC, data releases and methods A. Krone-Martins (CENTRA/SIM, Univ. Lisbon)

12h30-14h Lunch (IAP)

3. The satellite Gaia: Extragalactic results, data processing and models

14h-14h45 : Review: The Radial Velocity Spectrometer (RVS): a spectrograph on-board Gaia

D. Katz (Obs. Paris Meudon)

14h45-15h15 : Quasar redshift determination through weighted PCA

L. Delchambre (Univ. Liège)

15h15 – 15h45 : Gaia and the GRAVITY experiment T. Paumard (Obs Paris-Meudon) TBC

15h45- 16h15 Coffee break

16h15-16h45 Calculating the absolute magnitudes of Quasars A. Andrei (GPA, Rio Janeiro)

16h45-17h15 Discussion on QSOs, Galaxies and clusters

17h15-18h30 Splitter meeting (salle des séminaires)

Friday July 10th

4. Astrometric catalogs and Reference systems

9h30- 10h15: Review : The construction of ICRF-2 and next ICRF3 C. Jacobs (JPL)

10h15-10h45: Multi wavelength reference frame activities B. Dorland (USNO)

10h45-11h15 Coffee-break

11h15-11h30 : Review : Astrometric catalogues & radio-optical link N. Zacharias (USNO)

11h30-12h00 : Aligning VLBI and Gaia extragalactic celestial reference frames: source selection G.

Bourda (Obs.Bordeaux)

12h00 -12h30: On the selection of astrometric radio sources for ICRF-GCRF link
Z.Malkin (Pulkovo)

12h30-14h00 Lunch(IAP)

14h00 - 14h30 : Understanding the differences between radio and optical positions of ICRF sources
V. Makarov (USNO)

14h30 - 14h45 : The LQAC : presentation and applications to the ICRF C. Gattano (Obs. Paris)

14h45 - 15h00 : A complete bank of optical images of the ICRF QSOs A. Andrei (GPA,RioJaneiro)

15h00 - 15h30 : Ties between kinematics and dynamic reference frames (D-VLBI) J.Anderson (GFZ)

15h30 - 16h00 Coffee break

16h00-16h30 : Investigation of EOP for VLBA calibration Survey sessions D. Mayer (FHG)

16h30-17h30 : *Final discussion : future of combined observational programs etc…*

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