



GREAT/ESF Workshop 3546

'Orbiting couples: "pas de deux" in the Solar System and the Milky Way'

Paris Observatory, October 10-12, 2011

<http://wwwhip.obspm.fr/PasDeDeux>

1. Summary

Binary and multiple systems are ubiquitous and are the best way to determine masses. Multi-epoch missions such as the European Gaia mission now offer the prospect of a large amount of new mass determinations whether for binary stars, exoplanets or binary Solar System objects. During two days and a half, the workshop has brought together these three different communities to share new challenges and insights related to orbit determinations and their astrophysical exploitation.

Organisers : Frédéric Arenou & Daniel Hestroffer, Observatoire de Paris

Scientific Organising Committee

- Frédéric Arenou (Observatoire de Paris, Fr.)
- Krzysztof Gozdziewski (Nicolaus Copernicus University, Pol.)
- Daniel Hestroffer (IMCCE, Obs. Paris, Fr.)
- Jose-Luis Ortiz (Instituto de Astrofísica de Andalucía, Esp.)
- Dimitri Pourbaix (Université Libre de Bruxelles, Bel.)
- Alessandro Sozzetti (Osservatorio Astronomico di Torino, It.)
- Paolo Tanga (Observatoire de la Côte d'Azur, Fr.)

Paris Local Organising Committee :

- Frédéric Arenou
- Panagiotis Gavras
- Daniel Hestroffer
- Annick Oger
- Cécile Veneau

2. Description of the scientific content of and discussion at the event

Orbits of visual binaries began to be computed at the middle of the XIXth century, and spectroscopic binaries and eclipsing binaries were discovered at the end of that century; by the end of the XXth century, the first exoplanets and the first binary asteroids were found. Although at first sight there seems to be a low connection between the problematics related to the multiple stars, the exoplanets, and to the Solar System, the problem of orbit determination

actually appears as a common concern among these very different communities.

Over the time, many orbit determination methods have been – and are still being – developed, not simply due to the various dimensions of the data (astrometric, photometric, spectroscopic, Light-Travel Time, etc.); still, only a small number of masses are available. In this respect, the advent of the astrometric (but also photometric and spectroscopic) Gaia survey will bring a considerable quantitative change as hundreds of binary asteroids, thousands of exoplanets or millions of stellar binaries are expected. As a side effect, the considerable size of these samples implies that the processing of the Gaia data consequently requires non-artisanal methods. Also, the scientific content, and possibly biases, will be statistical by nature, and the data will often have to be subsequently combined to complementary external data to improve the orbital elements and allow better mass estimations.

Discussing these points, the main aim of the workshop was to foster communication between different communities to take benefit from their different expertises and promote future collaborations, in particular to allow a better exploitation of the Gaia outcome.

The subject discussed have been the following:

- the solar system objects, stars and exoplanets, in binary and multiple systems;
- the different methods of orbital motion detection and orbital fit;
- the associated problems (stability, relativistic effects,...), biases and uncertainties;
- the different kinds of techniques and measures, or types: resolved binaries, astrometric binaries, spectroscopic, eclipsing,... and the combination of methods and data;
- with more focus on astrometry and the potential of Gaia in massive orbit determinations.

Accordingly the agenda was divided into several sessions, beginning with an illustration of the general challenges in each of the fields:

- introduction
- solar system binaries
- exoplanets
- binary stars

On the second and third day, all fields were mixed up on purpose in order to ease the discussions between communities, with the following sessions :

- photometry
- radial velocities
- associated problems and techniques

While radial velocities techniques remain a classical method for binary stars and exoplanets orbit determination, it was apparent in this meeting that photometry brings a promising large volume of new orbits in all fields, as it also give access to the fundamental parameters unveiling the physical nature of the objects.



3. Assessment of the results and impact of the event on the future direction of the field

As an all-sky astrometric, photometric and spectroscopic survey, Gaia is expected to provide phase space parameters for about one billion stars and hundreds thousands of asteroids, but it will also give fundamental astrophysical information for a very large fraction of these, and object masses and formation characteristics are one of the very important outcomes of the mission.

The Gaia Data Processing and Analysis Consortium assembles rather artificially in a single group, the CU4 Coordination Unit, the data reduction for everything which is not single stars. Scientist from the solar system field are side by side with binary stars or exoplanet specialists, though mostly without scientific communication between groups. It was recently realised that these groups could very usefully share their expertises about one common problem, the determination of orbits and masses, and this gave birth to the idea of this joint workshop.

In line with the GREAT objectives, the rationale of the workshop has been to draw the attention of the astronomical community to the Gaia outcome, bringing together the scientific expertises, a cross-fertilization potentially permitting to improve the methods and techniques and consequently the Gaia astrophysical gain. It should be stressed that although the Gaia data processing itself needs special techniques, and although the orbital parameters and masses directly obtained by Gaia are important to discuss, a very large improvement is expected to come through the combination of the intermediate Gaia data with high precision external data, but this will not always be that obvious.

Typical problems are associated with detecting shallow eclipses and the statistical analysis of large samples of light-curves, including gauging the ensemble properties of the detected systems. Combining transit photometry and radial-velocities is another issue, particularly when it comes to rejecting complicated configurations of 'impostors'. Devising efficient methods for fitting RV and astrometric data, not forgetting that precision RV determinations alone already suffer from problems such as stellar activity. Also, the implications of large sample of accurate astrometric mass determinations (together with the information brought by the orbital parameters) for exoplanets or binary asteroids for the purpose of improving the understanding of the formation models, has been discussed in detail. Numerous other astrophysical exploitations have been discussed such as the influence of third bodies (or more).

The choice of speakers has reflected the various (and possibly cross-domains) techniques and astrophysical applications. They have been chosen such as to represent the competence in their field, but also as mostly outside the Gaia community.

This workshop was timely as it will allow developing the needed methods in advance to the Gaia data and provide a “first contact” between the concerned communities. In a second step, it is well possible that further conferences will take place, such as a “Ménage à trois” after the “Pas de Deux” one, devoted to the issue of stability in multiple systems.

The proceedings of this workshop will be published beginning of next year by IMCCE. The deadline for receiving manuscripts has been fixed to December 31, 2011.

4. Final programme of the meeting

Monday Oct 10, 2011

- [Forewords](#) (F. Arenou + D. Hestroffer) 30'
- [When size matters](#) (D. Pourbaix + P. Tanga) 30'

Coffee Break

[Session : solar system binaries]

- [Solar system binaries and triples : properties, origin, and evolution](#) (J.-L. Margot) 30'
- [Resolved binaries among TNOs, statistical inversion](#) (W. Grundy) 30'
- [Discovery and Characterization of Trans-Neptunian Binaries in Large-Scale Surveys](#) (A. H. Parker) 20'

Lunch

[Session : extrasolar planets]

- [Occurrence of Planets with radius and period](#) (G. Marcy) 30'
- [High-precision RV measurements in the GAIA era](#) (D. Queloz) 30'
- [Astrometry and Exoplanets Characterization : Gaia and its Pandora's Box](#) (A. Sozzetti) 20'

Coffee Break

[Session : binary stars]

- [Speckle interferometry of binary stars](#) (B. Mason) 30'
- [The mass-ratio distribution of binary stars](#) (H.M.J. Boffin) 20'
- [Binaries with A-type primaries - A comparison between dynamical masses and theoretical models](#) (R.J. De Rosa et al.) 20'

Cocktail (18h, Bâtiment Perrault, salle Cassini)

Tuesday Oct 11, 2011

[Session : photometry]

- [Eclipsing binaries : why, how, and what next ?](#) (J. Southworth) 30'
- [Orbit determination of eclipsing binary asteroids from photometry](#) (P. Scheirich) 30'
- [Kepler and Orbiting Triples : Pas de Trois](#) (D. W. Latham) 30'

Coffee Break

- [Photometric detection of non-transiting short-period binaries through the BEaming, Ellipsoidal and Reflection effects in Kepler and CoRoT lightcurves](#) (T. Mazeh) 30'
- [Binaries densities from light curves and stellar occultations](#) (F. Colas) 20'
- [Towards an Automated Processing of Gaia Eclipsing Binaries](#) (C. Siopis) 20'

[Session : radial velocities]

- [Stellar wobble in triple star systems](#) (A.C.M. Correia et al.) 30'

Lunch

- [Probing exoplanet population synthesis models with large samples of RV \(and Gaia astrometric\) orbits](#) (C. Mordasini et al.) 30'
- [Spectroscopic binary processing within Gaia DPAC](#) (Y. Damerджи) 20'
- [When will we be able to discover exosatellites ?](#) (P. P. Campo et al.) 20'

- [Extending the GAIA planet catch by combining with precise radial velocities](#) (M. Neveu et al.) 20'

Coffee Break

[Session : associated problems and technics]

- [Planetary satellites as a N-body problem in the solar system](#) (V. Lainey) 30'
- [Precision measurements for binary pulsars](#) (M. Kramer) 30'
- [Astrometry of TNOs to characterize astrometric binaries in the solar system](#) (A. Thirouin) 20'

[Social dinner](#)

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Wednesday Oct 12, 2011

- [Orbital inverse problem and binary asteroids](#) (D.A. Oszkiewicz) 20'
- [Could Gliese 22 Bb be detected by direct imaging ?](#) (M. Andrade) 20'
- [Limitation of the TTV technique for the detection of new planets](#) (G. Boué) 20'
- [Dynamical analysis of the nu Octantis planetary system](#) (K. Goździewski) 20'

Coffee Break

- [Interferometry, spectroscopy and high-precision astrometry of the bright eclipsing binary Delta Velorum](#) (P. Kervella) 20'
- [Approximation of the gravitational potential of a non spherical asteroid : application to binary and triple asteroidal systems](#) (A. Compère et al.) 20'
- [Astrophysical noise in the astrometric detection of exoplanets](#) (J. Schneider) 20'
- [Orbital characterisation of binaries from Monte Carlo inversion](#) (D. Hestroffer) 20'

5. Participants

Andrade Manuel	Astronomical Observatory R.M. Aller - Universidade de Santiago de Compostela
Arenou Frédéric	GEPI, Observatoire de Paris, CNRS, Université Paris Diderot
Baidolda Farida	Observatoire de Paris
Boffin Henri	ESO
Boué Gwenaël	Centro de Astrofísica da Universidade do Porto
Campo Díaz Pedro	Observatorio Astronómico R.M. Aller- Universidade de Santiago de Compostela
Colas Francois	IMCCE - Observatoire de Paris
Compère Audrey	Dpt of mathematics, University of Namur, Belgium
Correia Alexandre	University of Aveiro
Damerджи Yassine	Institut d'Astrophysique et de Géophysique de Liège
De Rosa Robert	University of Exeter
Delisle Jean-Baptiste	IMCCE - Observatoire de Paris
Docobo Jose-Angel	Observatorio Astronómico R.M. Aller- Universidade de Santiago de Compostela
Gavras Panagiotis	Observatoire de Paris, Meudon
Goździewski Krzysztof	Torun Centre for Astronomy
Grundy Will	Lowell Observatory
Hestroffer Daniel	IMCCE/Observatoire de Paris
Kervella Pierre	Observatoire de Paris
Kramer Michael	Max-Planck-Institut fuer Radioastronomie
Lainey Valery	IMCCE-OBSPM
laskar Jacques	Observatoire de Paris
Latham David	Harvard-Smithsonian Center for Astrophysics
Libert Anne-Sophie	University of Namur
Liller William	Centro de estudios de novae
Marcy Geoff	UC Berkeley
Margot Jean-Luc	University of California, Los Angeles
Mason Brian	US Naval Observatory
Mazeh Tsevi	Tel Aviv University



Merand Antoine European Southern Observatory
Morais Helena University of Aveiro
Mordasini Christoph Max Planck Institute for Astronomy
Neveu Marion Geneva University
Oszkiewicz Dagmara Anna University of Helsinki
Parker Alex Harvard-Smithsonian Center for Astrophysics
Porter Simon Lowell Observatory
Pourbaix Dimitri FNRS @ ULB
Pravec Petr Ondrejov Observatory
Queloz Didier Geneva University
Quirrenbach Andreas Landessternwarte Heidelberg
Rambaux Nicolas UPMC - IMCCE - Observatory Paris
Sahlmann Johannes Observatoire de Geneve
Scheirich Peter Astronomical Inst. of ASCR, Ondrejov
Schneider Jean Observatoire de Paris
Siopis Christos Université Libre de Bruxelles
Southworth John Keele University, UK
Sozzetti Alessandro INAF - Osservatorio Astronomico di Torino
Tanga Paolo Observatoire de la Côte d'Azur
Thirouin Audrey Instituto de Astrofisica de Andalucia (IAA,CSIC)
Turon Catherine GEPI, Observatoire de Paris