Proceedings of

Gaia Follow-up Network for Solar System Objects Workshop held at IMCCE-Paris Observatory

2010, November 29 – December 1

Institut de mécanique céleste et de calcul des éphémérides
Observatoire de Paris

Dépôt légal – juin 2011
ISBN 2-910015-63-7

Foreword

This workshop was dedicated to the setting-up of a follow-up network for the Solar System Objects observed by the Gaia mission. After several years for getting in touch with candidate observers in many different countries, it was an important step aiming at accompanying this space astrometry mission all along its five year observation period. This workshop allowed us to know more on the status of the project, to propose a work flow for the processing of alerts, to get precise information on the observing sites and their specificities, to organize discussions and try to answer to some questions, to meet each other, to have fruitful exchanges and to simply reinforce the international collaboration. But most of all it was the opportunity to make this network active, and to foresee further actions. These proceedings provide a large overview of the communications and will be a reference document for the setting up and operation of the Gaia-FUN-SSO network. However, some open questions remains. Among them, the number of alerts is probably one of the most important unknowns, since it determines the work load to be carried on by the network, both by the central node and by the observing sites. Another important question appeared and could not be solved: the needs of funding for some observing sites. During the period of time before the launch of Gaia, we hope to get answers to these points.

We would like to thank all the participants to this fruitful meeting.

Paolo TANGA & William THUILLOT
Co-chair of the Gaia-FUN-SSO workshop

Acknowledgements

■ The Gaia-FUN-SSO workshop has been organized thanks to the following people :

– The members of the Scientific Organizing Committee:

- Jean-Eudes Arlot, IMCCE-Paris Observatory, France
- Jérome Berthier, IMCCE-Paris Observatory, France
- Alberto Cellino, Torino Observatory, Italy
- Daniel Hestroffer, IMCCE, France
- Francois Mignard, OCA, Nice, France
- Paolo Tanga (co-Chairman), OCA, Nice, France
- Rama Teixeira, IAG-USP, Sao Paulo, Brazil
- William Thuillot (co-Chairman), IMCCE-Paris Observatory, France
- Zheng Hong Tang, Shanghai Astronomical Observatory, China

– The members of the Local Organizing Committee:

- Jean-Eudes Arlot, IMCCE-Paris Observatory
- Alrick Dias, IMCCE-Paris Observatory
- Maryse Dufay, IMCCE-Paris Observatory
- Daniel Hestroffer, IMCCE-Paris Observatory
- Isabelle Nicolas, IMCCE-Paris Observatory
- Agnès Patu, IMCCE-Paris Observatory
- William Thuillot (Chairman), IMCCE-Paris Observatory
- Cécile Veneau, IMCCE-Paris Observatory

– Several colleagues from IMCCE, in particular Yohann Gominet who deal with the design of the workshop poster, badges and the providing of this book of proceedings.

■ This workshop has received very helpful funds from several institutions:

- Action spécifique Gaia (wwwhip.obspm.fr/gaia/AS/AS-Gaia-bienvenue.html)
- Paris Observatory scientific council (www.obspm.fr)
- Observatoire de la Côte d'Azur (www.oca.eu)
- Institut de mécanique céleste et de calcul des éphémérides (www.imcce.fr)

Summary

Analysis of Astrometry and Photometry Observations of Asteroids at the RTT150

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Introduction

The space astrometric mission Gaia, a cornerstone of the European Space Agency, will be launched in 2012 with the objective to make a 3D precise map of our Galaxy. The Gaia will furnish positions, distances and motions of a billion stars with unprecedented precision. Beside stars, the Gaia will observe asteroids with unprecedented precision from 0.5 to 3 mas, allowing the extremely fine orbit determinations (Tanga et al., 2008). This precision has great significance for the determination of small effects influencing the dynamics (relativistic, gravitational, non-gravitational, etc.) of Solar system bodies. The determination of masses of a hundred asteroids with a relative precision better than 50% is expected in 5 years of Gaia operation (Mouret et al, 2007).

Considering the time length of the Gaia mission, there will be encounters between asteroids occurring either at the beginning or the end of the mission, so the maximum of deflection angle pertained to the perturbation maximum will not be observed. The precision of mass determinations based solely on the Gaia observations will deteriorate in such cases (Hestroffer et al., 2008). A possible way out consists of acquiring ground-based observations of high accuracy of selected asteroids and organizing a dedicated network (Thuillot, 2005). The RTT150 telescope is one of the professional telescopes, which has already shown its possibilities for researching orbital dynamics of asteroids (Aslan et al., 2006).

1. Astrometrical Results

The original list of Institut de Mécanique Céleste et de Calcul des Éphémérides (IMCCE) for astrometry measurements of asteroids consists of 279 perturbed asteroids to be observed during 2008-2010. If astrometrical accuracy of their positions is high enough, then they can be used for complementary science with the Gaia results, thus improving determination of masses for 27 asteroids, including Ceres and Vesta. The idea consists of recovering the orbits of the perturbed asteroids through accurate astrometrical ground-based observations spanned in time before the Gaia launch.

There are two difficulties in accomplishing this task: limited visibility of selected asteroids caused by changing their configuration with respect to the Sun and Earth, as the three year period is comparable to the synodic periods of main belt asteroids, and the limited allocated time for astrometrical observations of asteroids at the professional telescopes, allowing both aperture for imaging faint asteroids, appropriate field of view and scale for making

astrometrical measurements at the accuracy level of 0.1″ with contemporary astrometric catalogues.

The selection of asteroids for observations at the RTT150 telescope was made of those perturbed asteroids which can make possible of mass determination for as many as possible asteroids, and those ones perturbed by Ceres and Vesta, which have observed effect greater than 50 mas. The first group consisted of 48 asteroids and the second made up of 22 ones, 70 perturbed asteroids in total. There was calculated visibility for each selected asteroid for the time period of 2008-2010, consisted of apparent visual magnitude, zenith distance at the meridian, solar elongation. The final observational programme was made of those asteroids, whose visibilities were limited by magnitude less than 18, zenith distance at the meridian less than 70°, solar elongation greater than 90° for attaining the best achievable conditions for astrometrical observations.

In the given allocated time of 3 years, there were observed 45 perturbed asteroids at the RTT150, making up a catalogue of 2437 astrometry positions. The astrometric reduction was made with the UCAC2 and UCAC3 catalogues. For making analysis of astrometrical observations of asteroids, there were calculated mean differences *(O–C)* for each series of observations using the HORIZONS system. The resulting distribution is given in Figure 1.

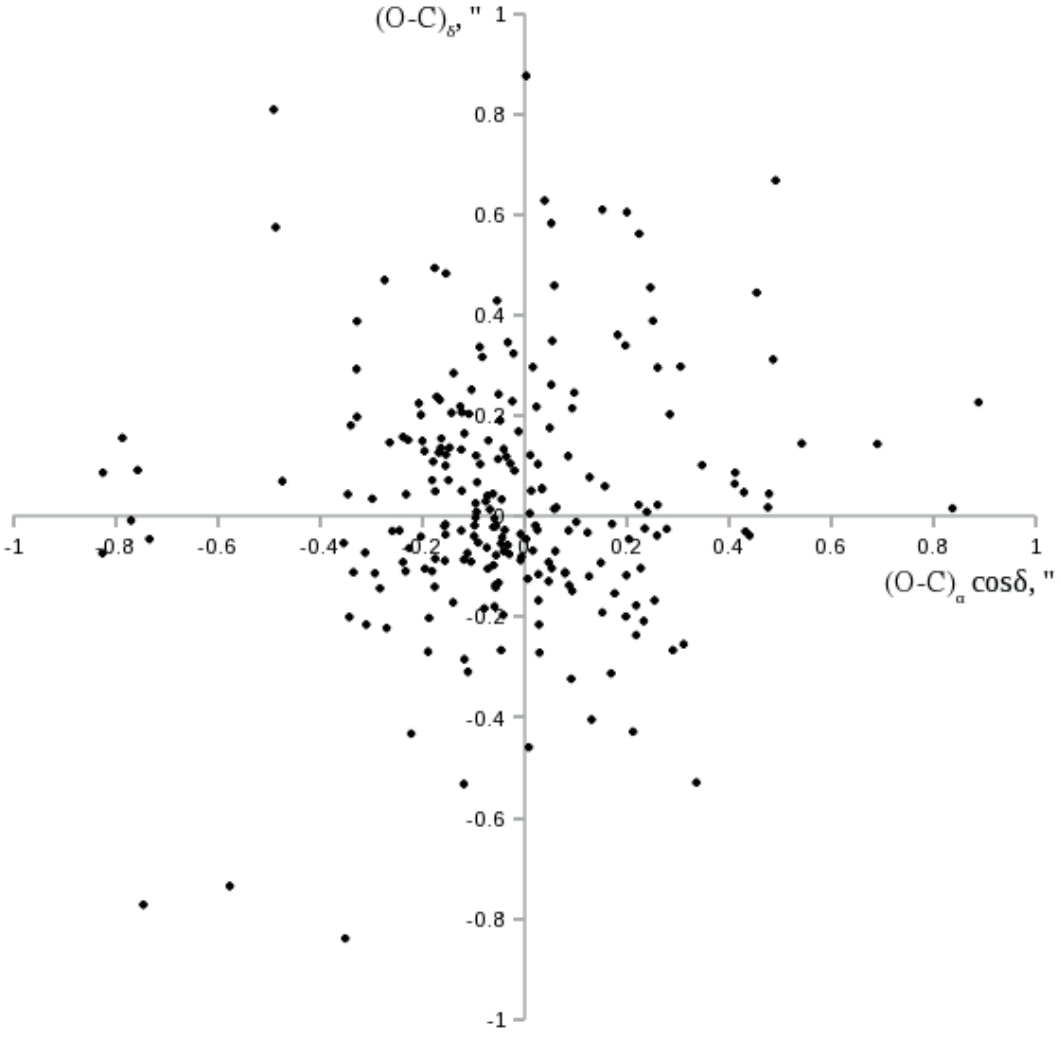

Fig. 1 – Distribution of *(O–C)* in position measurements of asteroids

Certainly, several points may belong to the measurements of one asteroid though in different nights.

The weighted errors of a single measurement are 0.16″ in right ascension and 0.13″ in declination. The standard error was calculated as a standard deviation of a single position from the mean one in the series of observation positions in one night. The weights for individual dispersions were assigned proportional to the number of positions in respective series.

Considering the above listed values of errors, the length of series greater than ten positions, one can expect to find significant discrepancies in *(O–C)* at the level 0.1″, assuming a normal distribution. As one can easily discover in Figure 1, the majority of *(O–C)* in both right ascension and declination described here has great "Student's ratio", and thus, the associated positions can be used for improving orbital elements of observed asteroids even now.

2. Photometrical Results

The differential photometry was made for all images where the reference stars of SDSS7 catalogue were present. The stellar magnitudes of SDSS7 were transformed to the BVR Johnson-Cousins-Bessel system using the adopted equations. Thus, there were photometrically reduced 1842 images. The weighted errors are 0.14 mag in B-band, 0.09 mag in V-band, 0.14 mag in R-band, which are greater than the best errors about 0.01 mag of the respective transformations, given by R. Lupton, on the site of SDSS Data Release 7 (http://www.sdss.org/dr7/algorithms/sdssUBVRITransform.html).

The light curve of one of the observed asteroids (35107) 1991 VH belonging to Apollo group is given below, Figure 2. The photometrical data represents observations made on June 28, 2008. The light curve shows changes of brightness with the period of variability about 0.1 day and amplitude about 0.2 mag. The error bars indicate standard errors, resulting from the signal-to-noise registered.

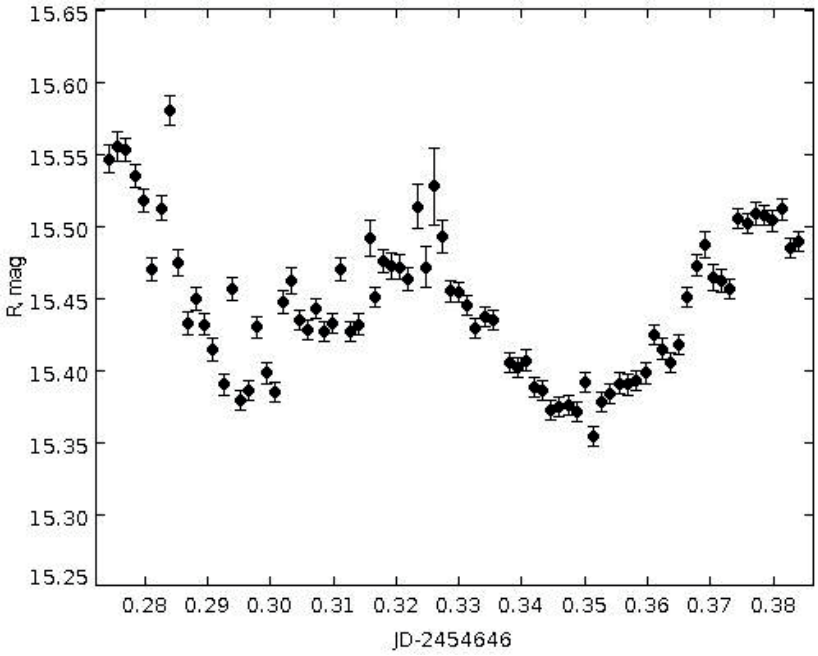

Fig. 2 – Light curve of asteroid (35107) 1991 VH

Conclusion

The telescope RTT150 is used for observations of perturbed asteroids under the observational programme made of the IMCCE list. There were observed 45 asteroids in 3 years run. The allocated time is a principal factor which limits the number of observed asteroids.

The achieved position precision is 0.16″ in right ascension and 0.13″ in declination and is limited by small effects of atmosphere and optics. There are possibilities to reduce precision less than 0.1″.

There was made differential photometrical reduction for 1842 images (82% of positions) in the BVR Johnson-Cousins-Bessel system. The weighted errors are 0.14 mag in B-band, 0.09 mag in V-band, 0.14 mag in R-band.

Acknowledgements

A.I. and G.P. express their gratitude to the Organizing Committee for the partial support of their stay during the Gaia-FUN-SSO Workshop. R.G. is partially supported by Russian Foundation for Basic Research, grant 11-02-00262-a.

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