

Proceedings of

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

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**Institut de mécanique céleste et de calcul des éphémérides
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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

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Summary

Gaia Science Status

by Timo PRUSTI, European Space Agency..... 11

Daily Processing of Solar System Object Observations by Gaia

by Paolo TANGA 15

Science from NEOs – Limitations and Perspectives

by Daniel HESTROFFER 21

Ground Based Optical Tracking of Gaia

by Martin ALTMANN, Alexandre H. ANDREI,
Ulrick BASTIAN, Sébastien BOUQUILLON,
François MIGNARD, Rick L. SMART, Iain STEELE,
Paolo TANGA & François TARIS 27

SYRTE and PARSEC Contribution for the GBOT/GAIA

Moving Target Astrometry

by Alexandre H. ANDREI, Sébastien BOUQUILLON, François TARIS,
Rick L. SMART & Martin ALTMANN 31

The Evolution of the Networks of Observers of Phenomena

by Jean-Eudes ARLOT 35

Gaia and ESA's Space Situational Awareness' Near-Earth Object programme

by Detlef KOSCHNY, Gerhard D. ROLSHAGEN & Benoit CARRY 43

Near-Earth Asteroids Astrometry with Gaia and Beyond

by David BANCELIN, Daniel HESTROFFER & William THUILLOT 47

Identification of Known SSO in CU₄ Object Processing

by Jérôme BERTHIER 51

Objectives and Management of the Gaia-FUN-SSO Network

by William THUILLOT 55

The Zadko Telescope: the Australian Node of a Global Network of Fully Robotic Follow-Up Telescopes

by David M. COWARD, Myrtille LAAS-BOUREZ & Michael TODD 59

Introduction of Astronomical Telescopes and Instruments in Yunnan Astronomical Observatory

by Jinming BAI & Zhong LIU 63

The Aosta Valley Astronomical Observatory

by Albino CARBOGNANI 67

Follow-Up Observation Plan on SSO of Purple Mountain Observatory

by Haibin ZHAO 73

Follow-Up and Search Capabilities of Asteroids and Comets in a Location in the Southern Hemisphere

by Gonzalo TANCREDI & the OALM's Team 77

C₂PU: 1-Meter Telescopes for the GAIA-FUN

by Philippe BENDJOYA, Lyu ABE & Jean-Pierre RIVET 81

PRAIA – Platform for Reduction of Astronomical Images Automatically

by Marcelo ASSAFIN, Roberto VIEIRA MARTINS, Julio I.B. CAMARGO, Alexandre H. ANDREI, Dario N. DA SILVA NETO & Felipe BRAGA-RIBAS 85

Astrometry with 1-Meter Telescope at Pic du Midi

by François COLAS (not received)

The 2-Meter Telescope of the National Astronomical Observatory Rozhen: Opportunities for Gaia-FUN-SSO

by Tanyu BONEV 89

Analysis of Astrometry and Photometry Observations of Asteroids at the RTT₁₅₀

by Anatolij V. IVANTSOV, Rustem I. GUMEROV, Irek M. KHAMITOV, Zekhi ASLAN, William THUILLOT, Gennadiy I. PINIGIN, Daniel HESTROFFER & Serge MOURET 93

Observation of NEOs Having High Apparent Rates with Mobitel Telescope

by Oleksandr SHULGA, Yevgen KOZYRYEV & Yevgeniya SYBIRYAKOVA 97

Observations of Asteroids in International Scientific Optical Network

by Yuriy N. KRUGLY, Igor E. MOLOTOV, Vladimir M. AGAPOV, Leonid ELENIN, Ninel M. GAFTONYUK, Vladimir V. KOUPRIANOV, Nasredin H. MINIKULOV, Makhmud I. GULYAMOV, Safarali ABDULLOEV, Zahari DONCHEV, Violeta IVANOVA, Alexander V. SERGEEV, Otabek A. BURKHONOV, Shuhrat EHGAMBERDIEV, Vasiliy V. RUMYANTSEV, Raguli Ya. INASARIDZE, Yury N. IVASHCHENKO, Boris SATOVSKIY, Chantal CAPPELLETTI, Alexander BARANSKY & Nikolay I. DOROKHOV 101

Science Alerts with Gaia

by François MIGNARD 105

**Astrometric Observations at the Konkoly Observatory:
Prospects for Gaia Solar System Follow-Up**

by Laszlo KISS & Krisztián SÁRNECZKY 111

**Astrometric and Photometric Observations of Solar System Bodies
with Telescopes of Pulkovo Observatory**by Alexander V. DEVYATKIN, Iraida A. VERESHCHAGINA, Eugene N. SOKOV,
Denis L. GORSHANOV, E. ROMAS, Ekaterina J. ALESHKINA, V.J. SLESARENKO,
Sergey KARASHEVICH, A.S. BECHTEVA, K.N. NAUMOV, Vladimir V. KOUPRIANOV,
S.V. ZINOVIEV & A.V. IVANOV 115**Modern Observations of Solar Systems Bodies on 65 cm Pulkovo's Refractor**by Natalia A. SHAKHT, Alexej A. KISELEV, Oleg P. BYKOV, Elena A. GROSHEVA,
Igor S. IZMAILOV, Olga V. KIYAEVA, Victor N. L'VOV,
Ludmila G. ROMANENKO & Svetlana D. TSEKMEJSTER 121**Status of a Latin American Contribution to the Follow-Up
of the Gaia Space Mission**by Ramachrisna TEIXEIRA, Alberto KRONE-MARTINS, André de C. MILONE,
Claudio C. MALLAMACI, Carlos E. LÓPEZ, Jesús H. CALDERON,
Iván H. BUSTOS FIERRO, M. FIDÊNCIO, José L. MUIÑOS,
Thais E.P. IDIART & Jorge E. HORVATH 125**Astrometry Correction for Chromatic Refraction**

by Anatolij V. IVANTSOV (poster) 127

**Astrometry of Asteroids with Normal Astrograph of Pulkovo Observatory:
from Digitized Plates to Modern CCD-Observations**by Evgeniya V. KHRUTSKAYA, Maxim Yu. KHOVRITCHEV, A.A. BEREZHNOY,
S.I. KALININ & Natalia A. SHAKHT (poster) 131**Opportunities for Follow-Up Observations of Solar System Objects
with 50/70 cm Schmidt Telescope of National Astronomical Observatory
Rozhen, Bulgaria**

by Andon KOSTOV (poster) 137

10 years of the IAU Efforts for Capitalizing the Ground-Based Astrometry

by Magda STAVINSCHI & William THUILLOT (poster) 143

**Gaia Follow-up Observations of the Solar System Objects with 1-m Telescope
(T100) at Tubitak National Observatory**by Mustafa HELVACI, Zeki EKER, Tansel AK, Ömür CAKIRLI, E. AYDIN, Ömer UYSAL,
Suleyman KAYNAR & Kadir ULUÇ (poster) (not received)**Author's Index** 147

Analysis of Astrometry and Photometry Observations of Asteroids at the RTT150

Ivantsov, A.¹, Gumerov, R.², Khamitov, I.³, Aslan, Z.⁴,
Thuillot, W.⁵, Pinigin, G.¹, Hestroffer, D.⁵, Mouret, S.⁶

¹ Nikolaev Astronomical Observatory, 1 Observatorna St., 54030 Mykolaiv, UKRAINE

² Kazan State University, 18 Kremlevskaya St., 420008 Kazan, RUSSIAN FEDERATION

³ TÜBİTAK National Observatory, Akdeniz Üniversitesi Yerleşkesi,
07058 Antalya, TURKEY

⁴ İstanbul Kültür Üniversitesi, 34156 Bakırköy, İstanbul, TURKEY

⁵ IMCCE, Observatoire de Paris, 77 Av. Denfert-Rochereau, 75014 Paris, FRANCE

⁶ Lohrmann-Observatorium, Technische Universität Dresden, 01062 Dresden, GERMANY

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.

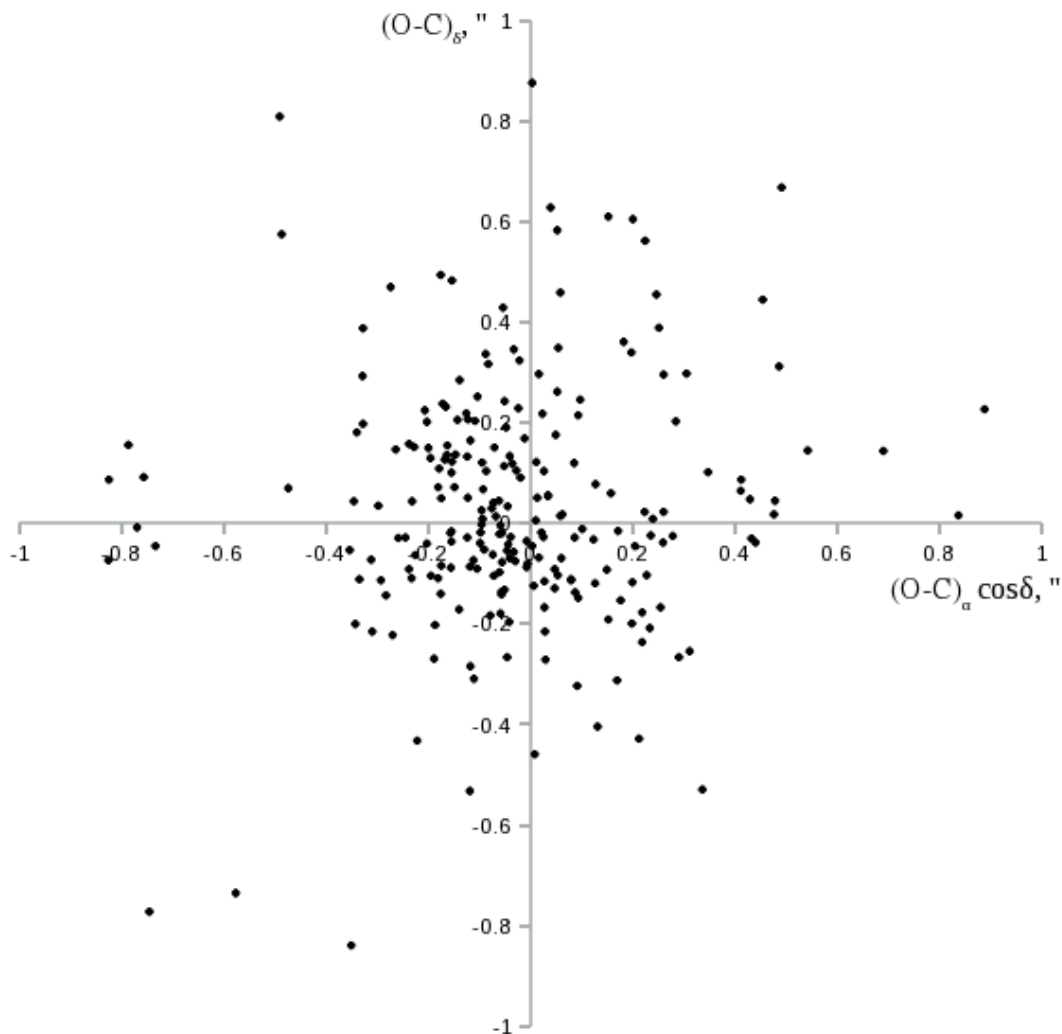


Fig. 1 – Distribution of $(O-C)$ in position measurements of asteroids

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.

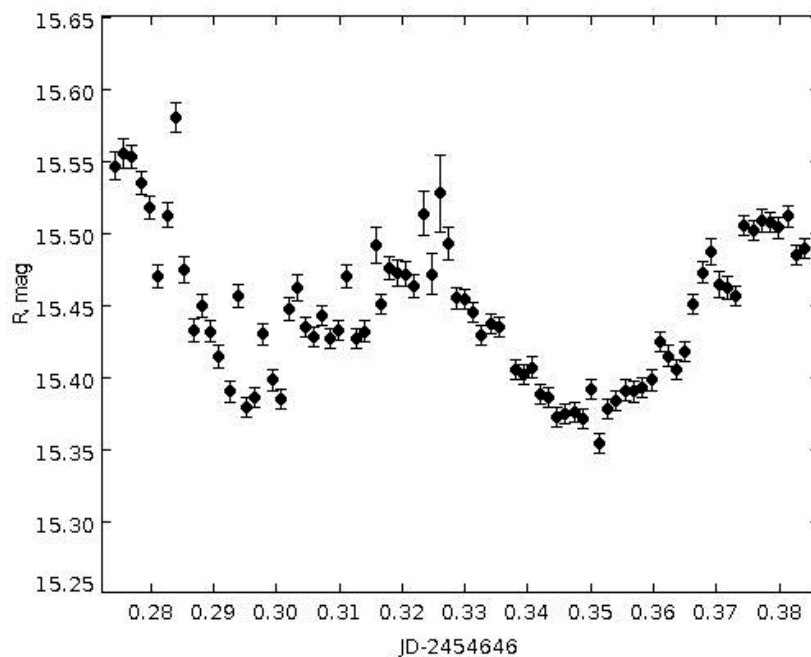


Fig. 2 – Light curve of asteroid (35107) 1991 VH

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.

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