A GROUND-BASED NETWORK OF OBSERVERS FOR A GAIA FOLLOW-UP

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ABSTRACT

During the Gaia mission, beyond the 3-D cartography of the Galaxy, we hope to get the detection of several transient events. In order to be able to exploit these detections and to perform further studies of these events, a ground-based network of telescopes would be very efficient.

Among the most common transient events, Gaia will probably detect a large number of new Solar System objects. Several among these objects will be fast moving objects, such as the Near Earth Objects and probably comets. A dedicated ground-based network will insure avoiding the loss of these objects.

Besides the astrometric parameters, ground-based observations will also allow us to quickly characterize several physical properties such as their photometric variability which is of interest for the identification of these objects in further measurements by Gaia.

This paper reports on some observational requirements for this follow-up programme and on the first attempts to build such a network

Key words: Gaia; Solar System; Asteroids; Network; Observation.

1. INTRODUCTION

During the Gaia mission, many transient events will certainly be observed and would require further investigations immediately after their detection. This will be the case for the detection of microlensing events, supernovae or gamma ray bursts. This will probably be also mainly the case for many detections of new Solar System objects and here we focus on this problem.

Since the satellite will continuously scan the sky according to its scanning law and will not have the possibility to monitor such events, these detections would be nicely supplemented by fast and further observations from some ground-based stations.

Therefore a network of observers could be an efficient solution in order to coordinate these actions and to increase the scientific return of the detections of transient events by Gaia.

2. WHAT KIND OF NETWORK WOULD BE REQUIRED?

In the same way as now, at the time of the Gaia mission we could obviously make use of the wide network of amateur and professional astronomers who currently exchange observational data thanks to several internet mailing lists.

The Minor Planet Mailing List (supported in part via the 2002 Shoemaker NEO Grant Program of The Planetary Society) is a good example of these lists in the field of the Solar System objects. This can be reinforced by the development and maintenance of a Gaia 'follow-up' web page where systematically newly discovered objects will be announced. Both actions would be very useful.

But, based on other experiences in the organization of observational campaigns, we think that a dedicated network could guarantee fast reaction to alerts and the right answers to specific requirements. Obviously it would be a stronger guarantee if some administrative acts link observatories with the Gaia staff. Nevertheless, the scientific teams already appear to be very interested by this project and the scientific collaboration to explore new objects of the Solar System.

The first task of such a network will be to keep track of newly discovered objects and to allow the improvement of their orbit in order that the identification by Gaia in subsequent observations would be possible.

This is why we tried to estimate the possibilities of ground-based CCD imaging in the context of an alert process. We intended to identify stations, with large longitude covering, where the research staff and instruments are adapted to CCD astrometric measurements.

This configuration (space satellite and ground-based network) may then avoid the common difficulties of all the actual surveys which are very efficient in the detection

of many faint asteroidal objects but cannot make further monitoring

3. WHAT WILL BE THE OBSERVATIONAL CONSTRAINTS ?

According to the capabilities of Gaia, we expect that numerous new small objects of the Solar System will be discovered during the mission. Several papers, such as those by Mignard (2002) or Bailer-Jones (2004), claim that much more than 100 000 new asteroids will be observed during the Gaia mission. Probably a rather large number of these objects will be fast moving objects such as Near Earth Objects.

In case of a detection, an alert could generally be done a few hours later and a provisional ephemerides would be calculated and sent to the network. A field of view of 0.5 degree will allow to find most objects a few days after the detection in their field of view and to get enough stars for the astrometric reduction.

Nevertheless several other important constraints could decrease the efficiency of a ground-based network. These constraints come from the following features.

3.1. Limiting Magnitude

Gaia will detect objects down to V magnitude 20, which is not really a problem for ground-based observation of slow moving objects with small and medium size telescopes ($<$ 2m). But, for fast moving objects (NEO will have apparent velocities of the range of 40 mas s^{-1}, a few could reach 100 mas s^{-1}) observers will have to make a compromise between time of exposure and quality of the image. They eventually have to track the object.

3.2. Solar Elongation

Due to the attitude of the probe (spin axis inclined to 50° from the Sun), many detections will be done at low solar elongation. Mignard (2001) in a simulation based on the analysis of numerous orbital parameters of NEO with limiting magnitude brighter than 20 showed that their solar elongations will have a distribution with two maxima: more than 25% of the objects are detected at a Solar elongation of 35° and about 5% with a Solar elongation of 140°. Such solar elongations may not systematically forbid ground-based observation (Hoeg & Knude 2001) dependig on their longitudes. Several telescopes can detect objects at elevation of 15° when the Sun is 15° under the horizon. But the faint magnitudes of these objects could be a supplementary difficulty.

3.3. Crowded Field of View

The new objects remaining to be discovered by Gaia during its mission will certainly present characteristics explaining why ground-based surveys did not catch them. Among these objects we will probably find not only the faint and fast objects, the objects at low Solar elongation, even orbiting inside the Earth's orbit, but also objects lost in crowded stellar fields. In this case, the interest of a network remains in the possibility to perform monitoring long enough to catch images of the objects between stars thanks to the geographical covering.

4. CANDIDATE STATIONS OF OBSERVATION

According to previous debates on the use of small telescopes and the thoughts about astrometric programmes (Kovalevsky 2002; Thuillot 2001; Stavinschi 2002, 2003), programmes of observations coordinated with space missions appear to be fine opportunities for carrying out very useful purposes.

Thus, we proposed the development of a Gaia follow-up programme to the IAU WG *Future developments in ground-based astrometry* of Commission 8 lead by M. Stavinschi and J. Kovalevsky (Thuillot & Stavinschi 2003; Thuillot 2004; Thuillot et al. 2004). A call for founding this network and other actions have allowed us to identify several possible stations at this date.

Table 1 shows the main information on the location, the telescopes and teams which declared an interest in this network.

Several of the telescopes have small diameters (at sites number 1, 5, 6, 9, 10, 11, 12, 13, 15) and will probably not be as efficient as the 0.50–1.5m classes of the other sites (2, 3, 4, 7, 8, 16). But, nevertheless, the automatic ones in particular could be of interest for fast monitoring of some bright new objects. Several robotic telescopes are proposed (sites number 2, 3, 6) and this is certainly a very interesting method to perform the tasks of this network.

5. CONCLUSION

Many transient events will be detected by Gaia during its mission. We hope in particular to detect several thousand new Solar System objects. By observing 'on alert', a ground-based network would therefore have two main objectives:

– To improve the provisional ephemerides and secure the identification of new objects by Gaia for subsequent observations after detection;

– To quickly characterize some physical parameters (for example search for variability and binarity by photometric measurements).

Furthermore, fast improvement of the ephemerides of asteroids thanks to this network will also permit further scientific developments to be carried out, for example:

– Immediate forecast of new stellar occultations useful for the size measurements from the ground;

– Updating of predictions of asteroidal close encounters in real time useful for the mass determinations by Gaia.

The actual list of sites of observation will be supplemented by robotic telescopes which appear to be very well adapted to the tasks devoted to a ground-based follow-up network.

We encourage observers to join this ground-based network for a Gaia follow-up programme.

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Table 1. The beginning of a Gaia follow-up network: teams and telescopes (L: refractors, T: reflectors)

Names	Location Instruments Diam./Focal length (m)	Number
Osborn W.	Brooks Obs., (Michigan, USA) T 0.4/4.9	1
Colas F.	Pic-du-Midi Obs. (France) T 1/17 or 5	2
	T 0.55/15.9 Automatic in development	
	T 1-2/- robotic in project	
Boer M.	OHP (St-Michel, France) T 1.2/7.2	3
	T 1/- Robotic ARAGO project partly funded	
Lagerkvist C. I.	Kvistaberg (Uppsala, Sweden) T 0.90/- Autom. B.Westerlund tel.	4
Kiseleva T. P. et al.	Pulkovo Obs. (Russia) L 0.3/3.4 Normal astrograph	5
	L 0.65/10.4	
Pinigin G. et al.	NAO, (Nikolaev, Ukraine) T 0.3/1.5 FRT robotic tel.	6
	T 1m Robotic in project	
Gumerov R.I. et al.	AOE, Kazan State Univ. (Russia) AZT-8 T 0.70/2.65	7
Aslan Z. et al.	TUG obs. (Turkey) Russian Turkish Tel. T 1.5/-	8
Teixera R. et al.	Abraho de Moraes (Valinhos, Brazil) T 0.36/1.3 Automatic tel.	9
	6 locations (Brazil) T 0.4/- Robotic tel. in development	10,11,12 13,14,15
Hou J. et al.	Sheshan station (China) T 1.56/15.6	16