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GROUND-BASED OBSERVATIONS OF SOLAR SYSTEM BODIES IN COMPLEMENT TO GAIA.

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Abstract. The ESA cornerstone mission Gaia, to be launched during end-2011, will observe $\approx 250,000$ small bodies. These are mostly main belt asteroids, but also Near-Earth objects, Trojans, and a few comets, or planetary satellites. The scientific harvest that Gaia will provide – given the high astrometric accuracy (at sub-milli-arcsec level), valuable photometric measurements (at milli-mag level), and moderate imaging (about 2,000 objects will be resolved) – will have a major impact on our knowledge of this population in terms of composition, formation and evolution (Mignard et al., 2007). There are nevertheless some intrinsic limitations in particular due to the unavoidable limited duration of the mission (5 years), the peculiar observing strategy that is not optimised to the observation of solar system objects, and last, the limited imaging possibilities. We can thus identify two kind of complementary data and ground-based observations, whether they are part of the Gaia Data Processing and Analysis Consortium (DPAC), or not, but provide a strong leverage to the Gaia science.

We discuss different aspects of additional observations from ground (yet not exclusively) either in preparation to the Gaia mission, in alert during the mission, or after the mission as additional complementary information. Observations of a set of well defined and selected targets, with different telescopes and instrumentation, will increase the scientific output in three particular and important topics: mass of asteroids, their bulk density and possible link to their taxonomy, and non-gravitational forces.

1 Gaia an ESA cornerstone astrometric mission

Gaia is the next space mission from the European Space Agency dedicated to astrometry. It is much more ambitious compared to its precursor Hipparcos, considering either the number of targets, the astrometric and photometric precision reached, or last the potential scientific outputs. For instance Gaia will enable the determination of asteroids taxonomy, spin state, and – for a smaller set – sizes, and masses. Nevertheless, the limiting magnitude and scanning law as well as the modest imaging resolution power, make that not all category of objects can be observed optimally. It is then interesting to complement such space data with dedicated ground-based observations. Such observations can be made on alert during the Gaia mission, but also either before or after the mission completion. Ground-based observations of asteroids and small bodies can be used a) for practical reasons during the data reduction itself, b) as supplementary data over larger time span, or c) as complementary data because out of the accessibility of the Gaia instruments.

2 Ground-based complements

Here we focus on a few points of interest:

1. Observations in alert will enable to trigger ground-based observations in short time (but not less than ≈ 24 hours) to ensure a good threading of the object, avoid its loss (and potential hazard), and complete

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the Gaia observations limited at $V \leq 20$ Tanga et al. (2008). These are delicate observations due to the possible low solar elongation, and the large parallax of the satellite located at the Sun-Earth L2 Lagrangian point;

2. High angular-resolution observations for selected asteroids will provide precise size and shape estimate and, once combined to good mass knowledge, their bulk density. Because there are no particular bias toward the binary asteroid population, and many taxonomic classes will be sampled, we will test for a possible link between asteroids' taxonomy and their interior (see Table 1). Additionally, these observations will be useful to calibrate the size determination from the Gaia imaging itself, and to calibrate the photocenter correction modelling to apply during the astrometric reduction;

3. Astrometric observations before and after Gaia of about more than 50 target asteroids will increase the number of derived asteroids masses (Mouret, 2007) adding more than 25 bodies to the list of approx. 150 from Gaia observations alone. Moreover, astrometry and radiometric size measurements of several selected NEOs will enable the detection of the Yarkovsky effect and possibly give an indication on their thermal inertia. These additional information will also enable us to better understand and model possible bias in the global adjustment of the complex model to the Gaia observations, avoiding hence a degradation of the general quality of any global parameter estimation (test of General Relativity, link of the dynamical reference frame to the optical ICRF, etc.);

4. Last, the availability of the Gaia stellar catalogue – together with better orbits of asteroids – will enable a much better prediction of stellar occultations, and their path on the surface of the Earth (see Fig. 1).

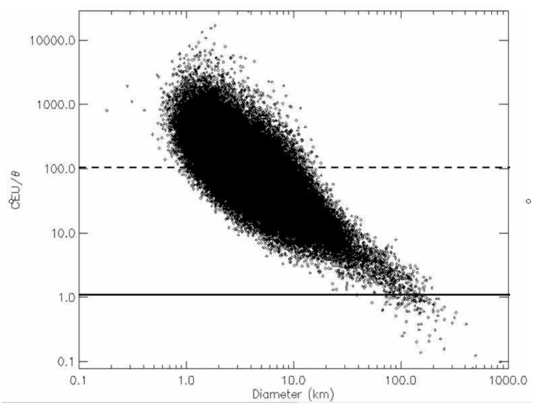

Fig. 1 Asteroids accessible to stellar occultations, as a function of their prediction precision and size. This is given by the ratio of the asteroids ephemeris uncertainty (CEU) to angular diameter θ as a function of the asteroid size. Good predictions are provided when $\mathrm{CEU}/\theta \leq 1$ thus an increase of one dex on the CEU precision would yield an increase of two dex in the number of potential asteroids, and also enable to sample smaller bodies (diameter $\gtrsim 10$ km). Compared to what can be achieved today with the Tycho catalogue, Gaia will yield a much larger number of interesting events; which in turn will be observed with a larger number of chords and not for only one snapshot, and consequently provide a completely scaled 3-dimensional view of the whole body.

Table 1. Taxonomic type sampling of asteroids with expected known masses (and apparent diameter ≥ 80 mas) observable at the VLT during forecoming ESO observations periods (covering 2 years).

Type	A	B	C	K	L	Q	R	S	T	X
P83	–	1	6	1	–	1	–	10	–	5
P84	1	–	7	–	–	–	–	4	–	4
P85	–	1	5	1	1	–	1	9	1	2
P86	–	1	5	1	–	–	–	6	–	3
Total	1	3	23	3	1	1	1	29	1	14

References

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