Local test of General Relativity

With Solar System Objects

Daniel HESTROFFER, P. DAVID, M. SAILLENFEST

Institut de Mécanique Céleste et de Calcul des Éphémérides

IMCCE/Observatoire de Paris, Paris **e-mail:** hestro@imcce.fr

Gaia, asteroids and PPN —

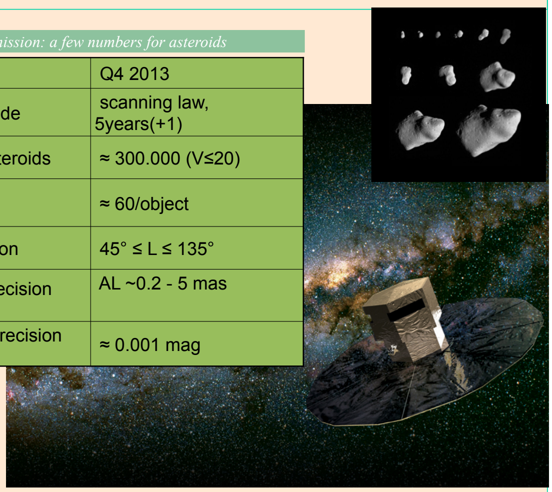
Gaia — the ESA astrometric space mission that will be **launched on 2013 November 20th** — is the successor of the pioneering Hipparcos/Tycho (1899-1993; 1997). This new mission is however much more ambitious considering the number of observed targets, the limiting magnitude, the kind of measures performed (mosaic of CCDs, spectro-photometry, radial velocity), the high precision photometry, and high accuracy ***global astrometry***. All positions are directly derived in an absolute reference frame materialised by the QSOs

Gaia will provide systematic survey of the whole sky down to magnitude 20, including observations of many solar system objects, mainly **asteroids**. (≈300,000), but also comets and satellites, etc. Gaia will also supersede Hipparcos with the catalogues that it will enable to construct (orbital elements, masses, diameters, taxonomy, spin state, …). The **photometric** and **astrometric** data will eventually provide the scientific harvest for SSOs [1].

Measures. The astrometric precision for a single observation is of the order of 0.2–3 mas, unprecedented for such SSOs! This will yield refined orbits and enable detection of non-gravitational forces and other small perturbations or accelerations, including the relativistic effects.

Gaia mission: a few numbers for asteroids

Launch date	Q4 2013
Observing mode	scanning law, 5years(+1)
Number of asteroids	≈ 300.000 (V≤20)
Aver. Numb. observations	≈ 60/object
Solar elongation	45° ≤ L ≤ 135°
Astrometric precision (1CCD)	AL ~0.2 - 5 mas
Photometric precision (1CCD)	≈ 0.001 mag



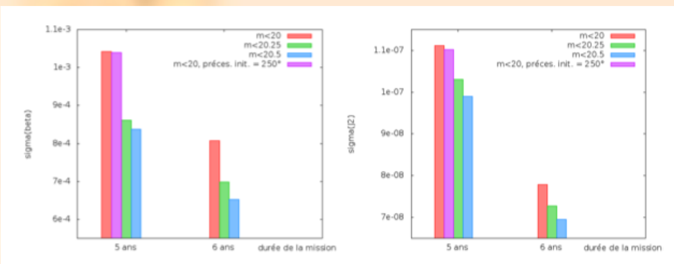
The Gaia satellite is to be launched on November 20th

Astéroids & local tests of GR —

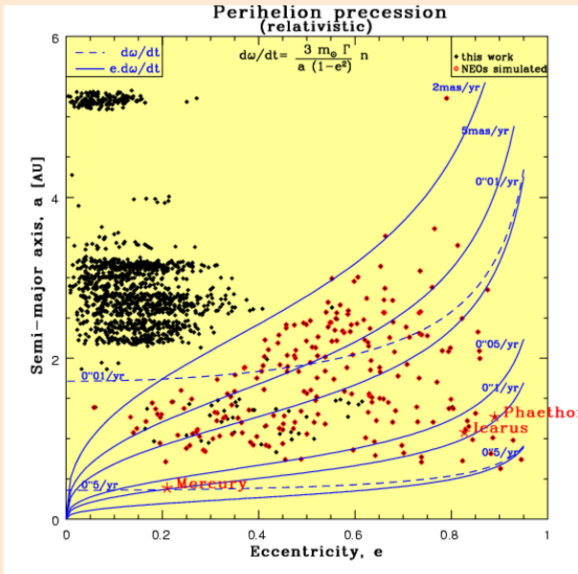
The satellite will observe many asteroids including about 1600 Near Earth Objects (NEOs), main belt asteroids, Jupiter Trojans and objects beyond the orbit of Saturn. Test of GR can be obtained through the determination of PPN parameters among others.

In particular one can derive:
- ➢ PPN β (simultaneously to J_2)
- ➢ Solar quadrupole J_2 (no stellar model)
- ➢ Variation of G $d(GM_\odot)/dt$
- ➢ Link of reference frames, dynamically non-rotating frame

In addition one can expect
- ➢ combination with other high quality data (Hipparcos, radar [2]) over longer time span
- ➢ testing alternative theories, e.g. post-Einsteinian [3], anomalous accelerations [4], strong equivalence principle [5], as well as sensitivity to Lense-Thirring
- ➢ improved results from a 1year mission extension



Results improvement from a one year Gaia mission extension. For the PPN parameter β and the Solar quadrupole J_2. ; considering only 500 objects. One gets a gain of a approx. x 1.5



Relativistic effect in the (a,e) orbital plane on the perihelion precession. NEOs with high eccentricity are as much sensitive to this effect as Mercury. Gaia will probe the whole plane enabling to derive simultaneously the PPN parameter β and the Solar quadrupole J_2.

References — bibliography

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