LOCAL TESTS OF GR WITH ASTEROIDS -- A GAIA PERSPECTIVE.

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Abstract: Asteroids, as massless particles, have been thought for almost half a century to be potential candidates for testing the General Relativity (GR). Indeed, GR can predict many effects observable in the Universe, but alternative theories exist that cannot be ruled out yet. Among the alternatives, metric theories can be combined — under the condition of weak field and low velocities, as present in the Solar System — into the parameterized post-Newtonian formalism (PPN, [1]). Asteroids orbits are affected by the planetary perturbations (and other perturbations) and the relativistic effects. Such perturbations can be measured from accurate astrometric measurements and orbit determination as is the case for e.g. the perihelion precession of Mercury.

The ESA cornerstone astrometry-mission Gaia, to be launched in 2011, will collect very precise and accurate position and velocities of a huge number of celestial bodies, including solar systems objects [2]. Among the approximately 300,000 asteroids brighter than V<20 that will be observed during the 5-year mission, the majority will be made of main-belt asteroids. However a substantial fraction of Centaurs, Trojans and Near-Earth objets (NEOs) should be observed too. Since not all NEOs are known yet, we also include in our analysis a synthetic population following debiased statistical distributions for the orbital parameters and brightness [3]. Taking advantage of the large number of asteroids acting as massless test-particles, and their distribution in the (*a,e*) plane of the orbital elements space, one can obtain original test of GR. In particular it is possible to derive—from a limited time-span—estimates of the PPN parameter β, expressing non-linearity of the theory, the solar quadrupole J_2, and a possible time variation of the constant of gravitation dG/dt. Others ways to be explored in more details are a possible measure of the Nordtvedt parameter η [4,5], showing violation to the Equivalence Principle, and extension to post-einsteinian gravitation [e.g. 6]. We show estimates of the expected precision of the parameters derived from a careful simulations of the Gaia astrometric data. This variance analysis takes into account—in a global treatment of all ≈300,000 targets—realistic precision and geometry of observations (which are very particular to Gaia), as well as mutual perturbations of asteroids [7]. Other possible effects, observational, gravitationnal, or non-gravitational, that can degrade the results are briefly discussed.

References:

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