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Scientific potential of the future space astrometric missions

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Abstract. We discuss the scientific potential of the future space astrometric missions.

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Visual and infrared astrometric observations from space have enormous potential for many branches of stellar and galactic astrophysics, solar-system research, cosmology and fundamental physics. The technical requirements for space astrometry are reviewed in very general terms. Considerations of diffraction and photon noise suggest that micro-arcsec astrometry is readily achieved with metre-size instruments, while nano-arcsec astrometry requires extremely challenging interferometry with 100 - 1000 m baselines. The 'parallax horizon' for trigonometric distances was some 100 pc for *Hipparcos*, and will be some 10 kpc for *Gaia* and 100 kpc for *SIM PlanetQuest*. This trend cannot be further extrapolated by a large factor even when nano-arcsecond astrometry becomes feasible, since the parallax method is less useful at cosmological distances, due to the paucity of sources that are both small (<1 AU) and luminous enough (thus extremely hot).

Gaia is a fully funded ESA mission, now in the detailed design and implementation phase (B2/C/D) with a planned launch in late 2011. During its 5 - 6 year lifetime, it will observe most point sources brighter than 20th magnitude, including ~ 1000 million stars, half a million of quasars and very large numbers of asteroids, extragalactic supernovae, etc. The expected accuracy of the positions at mean epoch, parallaxes and annual proper motions is about 7 μarcsec for bright (<12 mag) objects, 12 - 25 μarcsec at 15th mag, and 150 - 300 μarcsec at 20th mag. Quasi-simultaneous spectrophotometry will be obtained for all objects, using dispersed images at resolution $R \simeq 13$ - 30 in two wavelength bands. Radial velocities at 1 - 10 km/s precision will be determined for objects brighter than 16 - 17 mag using slitless spectra of the near-infrared Ca II triplet region.

The main impact of *Gaia* is expected in galactic and stellar research. Galactic studies will benefit from the flux-limited survey of all six components of phase space, including spectrophotometric classification. This will probe the distribution stars, dust and dark matter in the Galaxy, and identify dynamical processes such as density waves, bars, warps, and past merger events. In stellar astrophysics, the massive numbers of accurate trigonometric distances (e.g., $\sim 10^5$ better than 0.1 %, $\sim 10^7$ better than 1 %) for a wide range of stellar masses and evolutionary stages will provide new calibrators for stellar parameters and put new constraints on theoretical models. A detailed census of binaries and extrasolar systems within a few hundred pc will result, detecting Jupiter-size or larger companions to stars of all spectral types and providing unambiguous orbit and mass determinations. Half a million solar-system objects will obtain very accurate orbits allowing detailed dynamical analysis including many new mass-determinations.

The *Gaia* reference frame will be linked to ICRS through quasars (for a non-rotating frame) and optical counterparts of VLBI sources (for frame orientation). The expected accuracy is 0.5 μarcsec/yr for the rotation and 30 μarcsec for the orientation.