RADAR ASTROMETRY OF ASTEROIDS, COMETS AND PLANETARY SATELLITES

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Groundbased radar has considerable astrometric potential for asteroids, comets and natural satellites that enter the detectability windows of available telescopes. For very closely approaching asteroids and comets, measurements of the distribution of echo power in time delay (range) and Doppler frequency (radial velocity) can achieve a fractional precision between 10^{-5} and 10^{-9}, and consequently are invaluable for refining orbits and prediction ephemerides. Even for mainbelt asteroids and the more readily detectable planetary satellites, whose orbits are relatively well known, radar can collapse range uncertainties from a few target radii to a few percent of a target radius. Radar aperture synthesis can, in principle, complement delay-Doppler astrometry of small bodies by providing angular astrometry at a level approaching 0.01 arcsec.

Radar astrometry of a near-Earth asteroid (NEA) during its discovery apparition can ensure its optical recovery. Observational experience has demonstrated that radar astrometry commonly improves upon the accuracy of optical-only ephemerides of newly discovered NEAs by one to three orders of magnitude. Even for asteroids with very long astrometric histories and secure orbits, radar measurements can significantly shrink positional error ellipsoids for decades, with direct implications for the navigation of spacecraft to asteroids and predictions of extremely close approaches of asteroids to Earth.

Radar can image NEOs if the echoes are strong enough, and if the orientational coverage of the images is adequate, inversion of the data can yield a three dimensional model and an estimate of the delay-Doppler trajectory of the center of mass with very fine precision: a few decameters for work reported so far and a few meters for anticipated results of observations planed for the next few years.