Refining Preliminary Orbital Determination for Near-Earth Asteroids: Comparison of Fundamental Methods with n-Body Correction

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The accuracy of two fundamental techniques of orbital determination, Gaussian and Laplacian, was compared for three near-Earth asteroids (NEAs): 2010 TN54, 1998 QE2, and 1989 FC, chosen for visibility during angles-only observations and variability in physical orbital characteristics. The Gaussian method is based upon a Taylor series while the Laplacian method uses differentiation and Newton's method of linear approximation. I hypothesized that the method of Gauss would work most accurately as the Gaussian technique has a higher success rate than Laplacian for near-Earth objects. The Gaussian method produced accurate results for 2010 TN54 and 1998 QE2 but quite unreasonable values for 1989 FC; specifically, a large semimajor axis and an eccentricity close to one described an impossible orbit for an NEA. The Laplacian method gave reasonable but not completely accurate results; failures of both methods can be attributed to proximity to perihelion and Earth. A numerical integration method was coded to incorporate an n-body correction into both techniques; Euler's Three Body Problem was extended to seven massive moving bodies. Effectiveness of this correction was evidenced by improvement in accuracy of ephemeris generation. I can thus suggest that Gaussian and Laplacian methods be used with caution when asteroids are located near perihelion or Earth. Also, incorporating n-body correction into future orbital determinations will allow for better accuracy in predicting asteroid orbits and anticipating collisions with Earth.

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