Optimizing the Accuracy and Precision of Asteroid Orbital Determination: A Novel Approach

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Asteroid orbits are subject to chaos theory, that is, extremely sensitive to initial conditions. Because of this, it is critical to obtain both accuracy and high precision when generating the orbital elements of asteroids in order to accurately track their orbits and compute impact probabilities and position coordinates. This study focused on near-Earth asteroids, ones whose orbits might intersect with Earth's in the future. I studied ten asteroids in total in order to come up with a new way to optimize both accuracy and precision, especially over the short term period of a year. The need for a new method was demonstrated during 2013's close encounter with asteroid 2012 DA14, which we were not expecting to pass by so closely. Current methods of may not be as effective over the short range. Using the Gaussian method of orbital determination as a starting point, I calculated differences between the asteroid's projected position coordinates (measured in right ascension and declination, analogous to latitude and longitude) and calculated the changes in the six orbital elements (which define an asteroid's position in space) by feeding them back into an software program, which I wrote myself using the programming language Python. This program was calculates the orbital elements and generate ephemerides (tables of position coordinates as well as distance to Earth) to make corrections and generate new orbital elements. I found that this method of error analysis increases both accuracy and precision, I tested its statistical significance by performing a two-sample T-test, and might be best used for recently discovered asteroids to estimate impact probabilities and project their orbits into the future in a timely fashion, as well as factoring in gravitational perturbation.

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