The Mathematical Identification of Exoplanet Candidates through N-body Simulations

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Current exoplanet discovery methods are limited by our capacity to observe planet-star interactions. I developed a method of discovering exoplanets using planet-planet interactions by programming an n-body simulation in Matlab. Accuracy was assessed by modeling the inner planets of the solar system. Next, known planets were modeled, and simulation dynamics were compared to observed dynamics. Deviations in the simulation suggested the presence of undiscovered exoplanets interacting gravitationally and were analyzed to calculate the orbital parameters and mass of the proposed exoplanet. The simulation accurately reflected the planets' orbital parameters and maintained an error of less than 600,000 km over the course of one orbit for each planet, 1% of the semimajor axis of Mercury. To simulate a system with undiscovered planets, Mercury, Venus, and Earth were modeled without Mars. The simulated orbits deviated from their observed orbits over time and Earth's orbit exhibited periodic peaks in deviations every 15.0-17.1 years. These peaks corresponded to intervals where the Mars-Earth interaction was strongest, when Mars' perihelion coincided with the planets' conjunction. Earth's orbital deviation was used to calculate Mars' parameters. The longitude of perihelion was calculated within 4.66°, or 1.39%, of the actual value. The orbital period and semimajor axis were calculated within 0.03% and 0.02%, respectively. The eccentricity and mass were calculated within 7% of the actual values. Overall, the implementation of this method could increase the efficiency of exoplanet searches and broaden the horizons for exoplanet discovery.

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