

Dynamical Constraints on a Hypothetical Planet Nine through N-Body Simulations

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Abstract

We investigate the dynamical constraints on the hypothetical Planet 9 (P9) arising from its gravitational influence on known Solar System bodies. An N -body numerical framework is first developed and validated by integrating the orbit of Neptune from its Keplerian orbital elements and relevant Solar System parameters. The resulting trajectory is compared with a reference ephemeris to quantify the accuracy of the numerical model.

P9 is then introduced as an additional gravitating body, and its mass, semi-major axis, perihelion distance, orbital orientation, and orbital phase are varied over a prescribed parameter space. For each configuration, the perturbation induced in Neptune's trajectory is evaluated relative to the reference solution. The resulting deviations are used to identify regions of P9 parameter space that are dynamically compatible with the adopted constraints on Neptune's orbital motion.

The model is subsequently extended to include the Sun, Jupiter, Neptune, P9, and a representative comet in order to investigate the long-term evolution of planetary and small-body orbits. Changes in orbital elements and trajectory deviations are analysed as a function of the physical and orbital parameters of P9. The study provides a numerical framework for constraining candidate P9 configurations and examining the possible role of a distant massive perturber in shaping the dynamical structure and long-term evolution of the Solar System.