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Orbit Classification in Exosolar Systems: An Analysis Based on the Eccentric Restricted Three-Body Problem

Context/Objective: This study applies the eccentric version of the restricted three-body problem (ERTBP) to classify trajectories in exosolar systems. While previous research has explored exoplanetary systems through various models, our contribution focuses on providing a systematic taxonomy of test particle trajectories, representing celestial bodies such as exoplanets, exoasteroids, exocomets, or exomoons. Our findings are particularly relevant for identifying allowable orbits for exomoons, as well as for Earth-like exoplanets.

Methods: Using a numerical approach from prior studies, we simulate the motion of test particles in an exosolar system with a Jupiter-like exoplanet on an eccentric orbit around its host star. We employ the ERTBP to account for the eccentricity of the orbits of the main bodies.

Results: Our analysis classifies the trajectories into chaotic and regular motion, identifying different types of ordered motion. We reveal that both total orbital energy and eccentricity significantly influence the dynamical properties of test particle trajectories.

Interpretation: The results show that eccentricity plays a critical role in determining the stability and type of motion, with chaotic regions arising near resonances. The distinction between chaotic and regular trajectories enables a better understanding of the long-term evolution of celestial bodies in such systems. Additionally, the taxonomy highlights regions where exomoons can have stable orbits.

Conclusion: Our research provides a comprehensive orbit classification framework that can be used to study the dynamical evolution of exosolar systems, with implications for understanding habitability and planetary migration.

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