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Stability of circumbinary planets

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In this work we present the latest developments in the problem of the stability of circumbinary planets and how to identify stable and unstable orbits in such systems. In this context, we carry out more than 3x10^8 numerical simulations of planets between the size of Mercury and the lower fusion boundary (13 Jupiter masses) which revolve around the center of mass of a stellar binary over long timescales. For the first time, three dimensional and eccentric planetary orbits are considered. The results of the numerical integrations are used to derive two critical borders: an outer border beyond which all planetary orbits are stable and an inner border closer to the binary below which all planetary orbits are unstable. In between the two borders, a mixture of stable and unstable planetary orbits is observed. We provide empirical expressions in the form of multidimensional, parameterized fits for the two borders that separate the three dynamical domains. Moreover, we train a machine learning model on our data set in order to have an additional tool for predicting stable and unstable motion. Both the empirical fits and the machine learning model are tested for their predictive capabilities against randomly generated circumbinary systems. The empirical formulae are also applied to the Kepler and TESS circumbinary systems, confirming the stability of the planets in these systems. Finally, the empirical fits are compared against previously derived stability criteria.

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