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Isles of regularity in a sea of chaos amid the gravitational three-body problem

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The 3-body problem poses a longstanding challenge in physics and celestial mechanics. Despite the impossibility of obtaining general analytical solutions, statistical theories have been developed based on the ergodic principle. This assumption is justified by chaos, which is expected to fully mix the accessible phase space of the 3-body problem.
We probed the presence of regular (i.e. non chaotic) trajectories within the 3-body problem and assessed their impact on statistical escape theories.
Our analysis reveals that regular trajectories occupy up to 32% of the phase space, and their outcomes defy the predictions of statistical escape theories. Our findings underscore the challenges in applying statistical escape theories to astrophysical problems, as they may bias results by excluding the outcome of regular trajectories. This is particularly important in the context of formation scenarios of gravitational wave mergers, where biased estimates of binary eccentricity can significantly impact estimates of coalescence efficiency and detectable eccentricity.
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