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Cliffhanger EMRIs: a new GW source for LISA

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In nuclear clusters, massive black holes (MBHs) are surrounded by numerous stars and compact objects. In these high-density environments, two-body interactions between orbiting objects occur frequently, potentially leading to the formation of extreme mass ratio inspirals (EMRIs). In this work, we present a novel post-Newtonian Monte Carlo approach to locally account for the effects of two-body relaxation on objects orbiting the MBH, without leveraging on the common approximation of orbit-averaging. We apply our method to study the formation ratio of EMRIs to direct plunges (DPs) as a function of the initial semi-major axis of the orbit around the MBH. While it is generally believed that this ratio approaches zero for large initial semi-major axes, where only DPs are expected, a recent study challenges this notion for low-mass MBHs. Our simulations confirm the existence of cliffhanger EMRIs, forming from initially wide orbits around MBHs with masses less than 10^6 solar masses. These EMRIs arise from failed DPs, as their orbits significantly shrink and circularise following a single pericentre passage of few gravitational radii. We test how the EMRI-to-DP ratio is influenced by different assumptions on the dynamics used to evolve the system and treatment of two-body relaxation. We find that post-Newtonian corrections greatly enhance the number of EMRIs formed, while the departure from orbit-averaging does not notably affect the EMRI-to-DP ratio. Our findings call for a reassessment of future LISA detection rates to account for this new gravitational wave source.

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