Relativistic Corrections to the CR3BP Framework with Rotating Primaries: A Fourier Series Approach

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We present a relativistic extension to the planar Circular Restricted Three-Body Problem (CR3BP) by incorporating Pseudo-Newtonian corrections with Kerr-like primaries, enabling the study of a test particle influenced by two rotating compact objects beyond the Newtonian limit. Within a synodic coordinate system, we examine the stability of collinear Lagrange points and construct both short- and long-periodic orbits around them, highlighting their dependence on the mass ratio μ and the Kerr perturbation parameter ε, which accounts for Non-Newtonian effects. Our analysis reveals that relativistic corrections modifies the overall structure and evolution of family of orbits, altering stability conditions and reshaping orbital topologies in comparison with classical CR3BP dynamics. For the purpose of astrophysical realism, we have also introduce an effective Kerr parameter (εeff) and demonstrate the first physical validation of this theoretical framework through its application to transient mergers events like those of Binary Black hole mergers, including GW190412. These results highlight the astrophysical significance of extending CR3BP dynamics into relativistic regimes providing new perspectives on the orbital behavior of compact binaries.