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Consistent dynamics of eccentric black hole binaries.

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Describing the dynamics of eccentric black hole binaries remains an open problem in General Relativity. Oscualting equations based on energy and angular momentum balance have been found inconsistent with predictions obtained via orbit averaging, particularly in the parabolic regime. This inconsistency arises from the gauge-dependent definitions of energy and angular momentum. We reparametrize these quantities to obtain gauge-independent definitions, leading to a consistent set of equations that fully describe the evolution of eccentric orbits across arbitrary eccentricities. These equations align with the expected orbit-averaged behavior at small eccentricities. Utilizing this consistent framework, we quantify the regime of validity for orbit averaging prescriptions, which are currently prevalent in gravitational wave astronomy.

Primary author: FUMAGALLI, Giulia (Istituto Nazionale di Fisica Nucleare)

Co-authors: Prof. GEROSA, Davide (University of Milano-Bicocca); LOUTREL, Nicholas (Istituto Nazionale di Fisica Nucleare)

Presenter: FUMAGALLI, Giulia (Istituto Nazionale di Fisica Nucleare)

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