Investigating the Variability of Accreting Binary Black Holes

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Abstract

Supermassive binary black holes accreting mass offer a rare opportunity to probe the strong-field limit of dynamical gravity by using the ambient gas as a sort of lighthouse. They are important multi-messenger sources, emitting nHz-mHz gravitational waves (GWs) and electromagnetic (EM) waves from radio wavelengths to cosmic rays. Even though such binaries in the GW dominant regime have not been found yet, prospects for finding them soon are high because they are bright over a large bandwidth. A key challenge still exists to distinguish their emission from that of accreting single black holes, or active galactic nuclei (AGN). Over the past decade of simulating these sources, using Newtonian and general relativistic codes with hydrodynamics or magnetohydrodynamics, the community has found that inhomogeneities or overdensities in the circumbinary disk can modulate the EM signal with a period related to the binary's orbital period. The hope is that this quasi-periodicity may be used, in conjunction with other evidence, to identify and characterize these systems with EM waves even before they are found in the GW sector. We will present our latest general relativistic magnetohydrodynamics simulations of accreting black hole binaries and show how a binary's EM and accretion variability depends on the binary's mass ratio and separation, and even on the gas's thermodynamic properties. Our latest post-process general relativistic radiative transfer analysis will also be communicated to demonstrate the importance of using a consistent thermodynamics-radiation model, and illustrate the roles Doppler boosting and accretion modulation play in producing a binary's variable emission.