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Seeing Spacetime by Proxy: Binary Black Holes in Gaseous Environments

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Even though binary black hole (BBH) systems are expected to come in a wide range of masses, only the mergers of supermassive black holes—at the centers of galaxies—are expected to live in gas-rich environments. The presence of matter opens up the possibility that gravitational aspects of the binary's interaction can be transmitted—to distant observers—electromagnetically via dissipation of gas motion. Matching theoretical predictions to observations of systems before and after merger has the potential to improve our estimates of merger rates, and tell us about the spin and mass distributions of supermassive black holes. Seeing the light from the precise moment of merger—if such a robust signature exists—presents us with additional information such as more evidence that black holes merge, how material behaves in the strong-field dynamical regime of gravity, and a new and independent class of redshift-distance measurements if found with accompanying gravitational radiation (as with LISA). All of these exciting possibilities require realistic predictions for how gas—which will likely be magnetized—responds to a BBH evolution. In this talk, we will provide a brief survey of past and current work on theoretical models of BBH systems with gas. The consequences of recent numerical relativity simulations on these electromagnetic signature models will be emphasized. Knowledge gleaned from simulations of single black hole accretion disks will be presented to explain the likely importance of initial conditions on the circumbinary disk. We will also describe our efforts towards accurately simulating magnetized BBH disks just prior to merger, and a disk's response to the binary's coalescence and recoil of the nascent black hole.