Variety in the Variability of Accreting Supermassive Binary Black Holes

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Accreting supermassive binary black holes are key multi-messenger sources for LISA, yet are challenging to simulate realistically as solving the radiation magnetohydrodynamics (MHD) equations over the full dynamic spatio-temporal range of the problem is computationally infeasible at present. We report on our collaboration's progress simulating these systems using general relativistic MHD simulations and dynamic GR. In order to cover a larger temporal range in one set of simulations, we constrain our view to the circumbinary disk region and measure the effects binary mass ratio, accretion disk size, and black hole spin have on the structure and variability of the accretion flow. We particularly emphasize how these parameters influence the overdensity feature, which orbits the binary near the edge of the cavity, since it is responsible for most of the electromagnetic emission's variability and variability is a key signature of a system being a binary. Extending to smaller length scales, we will report on simulations following accretion all the down to the event horizons so that we can begin to investigate how black hole spin affects mini-disk dynamics, accretion rate, and jet power. The novel computational methods enabling inclusion of the black holes in the domain, including multi-patch methods, will be described.