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Gravitational Waveforms of Black Hole Binaries

Gravitational wave detectors depend on theoretical waveform predictions to pick out extremely faint signals from background noise. We used a post-Newtonian expansion to create video models of the orbital paths of non-negligible mass binary black holes. These Mathematica simulations ran from the initial conditions to the innermost limit at the end of the inspiral, when the post-Newtonian expansion fails as an adequate approximation. Video and sonified versions of the corresponding gravitational waveforms were modeled and synchronized with each orbital path movie in order to simultaneously show all three modes describing the inspiral event.

In order to explore the innermost section of the orbit, we modeled the (non-dissipative) Kerr solution for a central, massive, spinning black hole orbited by a companion black hole of negligible mass and spin. Methods were developed for modeling an accretion disk by calculating the energies for test particles with identical angular momenta and varying radii in circular orbits around the Kerr black hole.