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Computing the spin tilt angles at formation from gravitational wave observations of binary black holes

The angles between the spins of binary black holes and the binary's orbital angular momentum (often known as tilt angles) give important information about the evolution of the binary. For instance, for the isolated binary formation channel, the tilt angles when the binary is formed give information about supernova kicks. One can obtain the tilt angles at the binary's formation computationally efficiently using precession-averaged evolution to (mathematically idealized) infinite separation. However, precession-averaged evolution is not accurate when the binary is close to merger, which is where one measures the spin directions using gravitational wave observations with ground-based detectors. Thus, one first has to evolve the spins backwards in time using orbit-averaged evolution and switch over to precession-averaged evolution once it is sufficiently accurate. We investigate the maximum orbital speed at which one can switch from orbit-averaged to precession-averaged evolution to obtain a given accuracy in the tilts at infinity. We also discuss our formulation of the precession-averaged equations that allows one to use them for mass ratios very close to unity, as one finds in some posterior samples for binary black hole events detected by LIGO and Virgo.

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