Accounting for Ringdown Mode-Mixing in Black-Hole Merger Waveforms

BERNARD KELLY, JOHN BAKER, NASA Goddard Space Flight Center — With rapid progress in numerical relativity recent years, the merger of comparable-mass black-hole binaries has become a reliable source of gravitational waveforms. The dominant harmonic modes \((l, m) = (2, \pm 2)\) are readily extracted and agree across research groups to high precision, making them suitable as raw material for high-accuracy template construction. However, examination of leading subdominant gravitational harmonic modes has revealed more complex behavior that impedes full modeling. For example, the \((3, \pm 2)\) mode, usually comparable to the \((4, 4)\) in power content near merger, shows a complex frequency oscillation after merger, when the system should be ringing down to a Kerr end-state with constant quasi-normal mode (QNM) frequencies. Analysis indicates some kind of mode-mixing between the nominal \((3, 2)\) mode and the dominant \((2, 2)\) mode. We discuss the possible sources of this mode-mixing in numerical wave-extraction algorithms, and how to mitigate it to produce better-behaved waveforms that can be used for parameter estimation in gravitational-wave data analysis.

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