

## Modeling the ringdown of binary black hole mergers

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The post-merger gravitational-wave waveform of binary black hole mergers can be well modeled by quasinormal modes during the late ringdown phase. The theoretical spectrum of modes that could be present in the ringdown is extensive, but in practice only a subset of them will be significantly excited. Focusing on non-precessing mergers, we determine the relevancy of different ringdown modes by extracting their amplitudes from numerical relativity simulations with minimal assumptions a priori. We find that in addition to the standard fundamental mode and overtones, other modes such as nonlinear modes, retrograde modes and mirror modes could also be relevant. Furthermore, we identify the time at which the quasinormal-mode model starts to be an adequate description of the ringdown, and we present fits of the amplitude of different modes as a function of the simulation parameters. Our results could be used to build a model for the ringdown.

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