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Binary Black Hole Merger: Symmetry and the Spin Expansion

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Abstract

Two spinning black holes emit gravitational waves as they orbit, and eventually merge to form a single black hole. How do the properties of the final black hole depend on those of the initial black holes? We regard binary black hole (BBH) merger as a map from a simple initial state (two black holes, with dimensionless spins \vec{a} and \vec{b}) to a simple final state (a Kerr black hole with mass m , dimensionless spin \vec{s} , and kick velocity \vec{k}). By expanding this map around $\vec{a} = \vec{b} = 0$ and applying symmetry constraints, we obtain a simple formalism that is remarkably successful at explaining existing BBH simulations, and makes detailed new predictions about the merger process. We discuss some astrophysical applications of our formalism.