Simulations of Black Holes and Gravitational Waves

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Gravitational wave detectors like LIGO are poised to begin detecting signals. One of the prime scientific goals is to detect waves from the coalescence and merger of black holes in binary systems. Confronting such signals with the predictions of Einstein's General Theory of Relativity will be the first real strong-field test of the theory. Until very recently, theorists were unable to calculate what the theory actually predicts. I will explain how notions of hyperbolicity played a crucial role in unraveling this problem. I will describe the recent breakthroughs that have occurred in the numerical calculations. One successful method uses a formulation of dubious hyperbolic nature. A second formulation that is manifestly hyperbolic and implemented with multidomain spectral methods is also successful, but may not be able to handle all cases of interest. There are clearly many problems in this field ripe for more thorough theoretical analysis. In the mean time, things are set up for an epic confrontation between theory and experiment.