Numerical Relativity

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The numerical solution of Einstein's equations of general relativity promises to become one of the most potent tools for understanding the complex behavior of strong dynamical gravitational fields. In particular, the tremendous international investment in gravitational wave observatories–which promise to open our first window on the universe looking outside electromagnetic spectrum–depends on our learning to interpret gravitational signals radiated from violent cosmic events, such as black hole collisions. This will require accurate numerical simulation of Einstein's equations of general relativity.

The Einstein equations form a system of ten second order nonlinear partial differential equations in four-dimensional spacetime which, while having a very elegant and fundamental geometric character, are extremely complex. Their numerical solution will surely require new ideas, as well as the application of state-of-the-art numerical methods from other areas of computational physics. Despite recent progress in various directions, the development of accurate, efficient, and validated algorithms for Einstein's equations remains a grand challenge. This talk aims to introduce some of the scientific, mathematical, and computational problems involved in the burgeoning field of numerical relativity, and to suggest directions of future research.