A NEW APPROACH FOR MODELING GRAVITATIONAL RADIATION FROM THE INSPIRAL OF TWO NEUTRON STARS

Abstract

by

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In this dissertation, a new method of applying the ADM formalism of general relativity to model the gravitational radiation emitted from the realistic inspiral of a neutron star binary is described. A description of the conformally flat condition (CFC) is summarized, and the ADM equations are solved by use of the CFC approach for a neutron star binary. The advantages and limitations of this approach are discussed, and the need for a more accurate improvement to this approach is described.

To address this need, a linearized perturbation of the CFC spatial three metric is then introduced. The general relativistic hydrodynamic equations are then allowed to evolve against this basis under the assumption that the first-order corrections to the hydrodynamic variables are negligible compared to their CFC values. As a first approximation, the linear corrections to the conformal factor, lapse function, and shift vector are also assumed to be small compared to the extrinsic curvature and the three metric.

A boundary matching method is then introduced as a way of computing the gravitational radiation of this relativistic system without use of the multipole expansion as employed by earlier applications of the CFC approach. It is assumed that at a location far from the source, the three metric is accurately described by a linear correction to Minkowski spacetime. The two polarizations of gravitational radiation can then be computed at that point in terms of the linearized correction to the metric.

The evolution equations obtained from the linearized perturbative correction to the CFC approach and the method for recovery of the gravity wave signal are then tested by use of a three-dimensional numerical simulation. This code is used to compute the gravity wave signal emitted a pair of equal mass neutron stars in quasi-stable circular orbits at a point early in their inspiral phase. From this simple numerical analysis, the correct general trend of gravitational radiation is recovered. Comparisons with (5/2) post-Newtonian solutions show a similar gravitational waveform, although inaccuracies are still found to exist from this computation. Finally, several areas for improvement and potential future applications of this technique are discussed.