NUMERICAL RELATIVISTIC HYDRODYNAMIC SIMULATIONS OF NEUTRON STARS

Abstract

by

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Developments in numerical relativistic hydrodynamics over the past thirty years, along with the advent of high speed computers, have made problems needing general relativity and relativistic hydrodynamics tractable. One such problem is the relativistic evolution of neutron stars, either in a head on collision or in binary orbit. Also of current interest is the detection of gravitational radiation from binary neutron stars, black-hole neutron star binaries, binary black holes, etc. Such systems expected to emit gravitational radiation with amplitude large enough to be detected on Earth by such groups as LIGO and VIRGO. Unfortunately, the expected signal strength is below the current noise level. However, signal processing techniques have been developed which should eventually find a signal, if a good theoretical template can be found. In the cases above it is not possible to obtain an analytic solution to the Einstein equations and a numerical approximation is therefore most necessary. In this thesis the Einstein equations are written using the formalism of Arnowitt, Desser and Misner and a conformally flat metric is assumed. Numerical simulations of colliding neutron stars, having either a realistic or $\Gamma = 2$ polytropic equation of state (EOS), are presented which confirm the rise in central density seen by [51, 89] for the softer EOS. For the

binary calculation, the results of Wilson et al. [89] are confirmed, which show that the neutron stars can collapse to black holes before colliding when the EOS is realistic and we also confirm results of Miller [56] and others that there is essentially no compression, the central density does not increase, when the stiffer equation of state is used. Finally, a template for the gravitational radiation emitted from the binary is calculated and we show that the frequency of the emitted gravitational waves changes more slowly for the [89] EOS, which may result in a stronger signal in the 50-100 Hz band of LIGO.