

BNS-NRDA: Numerical Relativity meets Data Analysis for Binary Neutron Stars

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Introduction

Astrophysical motivation

- Binary neutron stars are well-modeled by post-Newtonian point particles in inspiral, but finite size effects become more important near merger
- Is it possible to determine properties of neutron star matter from gravitational radiation?

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Outline

- Differences between BH/BH and NS/NS
- Inspiral/merger waveforms
- PN matching
- DFT and LIGO Noise curve comparisons
- SNR estimates

NS-NS instead of BH-BH

Masses of roughly $1 - 2M_{\odot}$ ($1.18 - 1.44M_{\odot}$ with high precision)

- Mass ratio small, $\eta > 0.22$
- Merge at high frequency, PN is excellent for detection

NS-NS instead of BH-BH

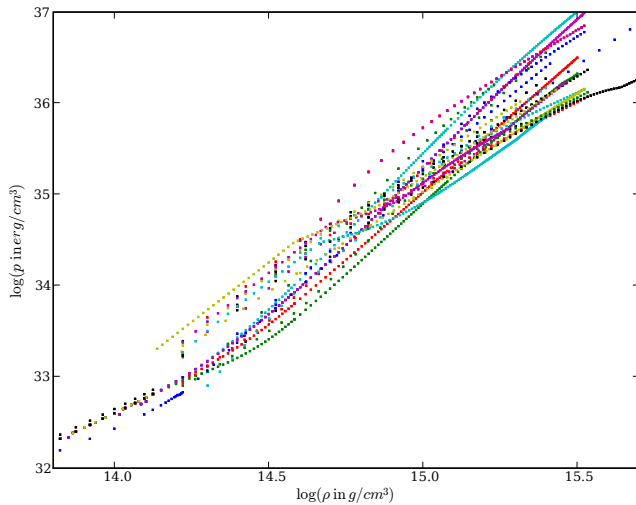
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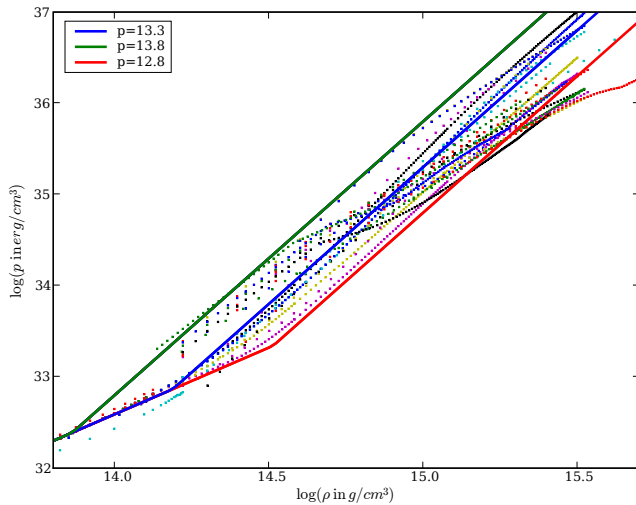
Matter!

- Matter sets the mass and length scale of a simulation
- Uncertainty in the equation of state

EOS and First Runs



EOS and First Runs



Numerical Simulation

Initial data

- Conformally flat
- Irrotational
- Equal mass, $1.35M_{\odot}$ neutron stars
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- BSSN with maximal slicing
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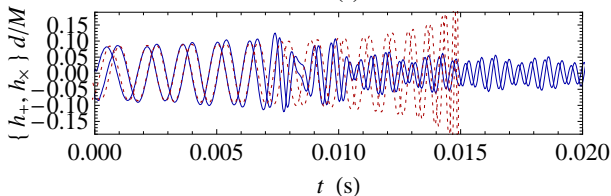
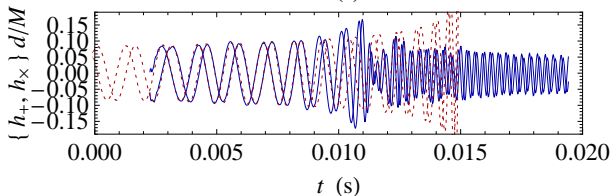
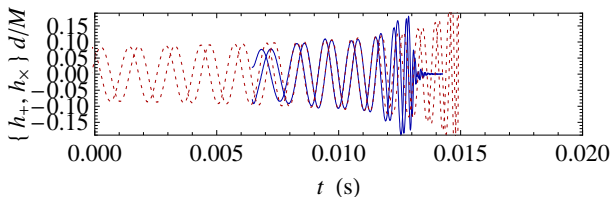
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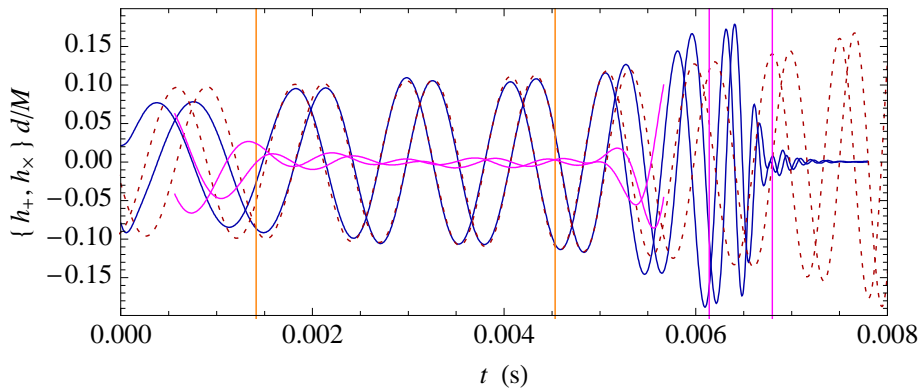
Gravitational wave extraction

- Wave zone metric decomposed into flat space + perturbation
- Gauge-invariant construction of each tensor spherical harmonic mode
- Quadrupole (2, 2) mode dominates

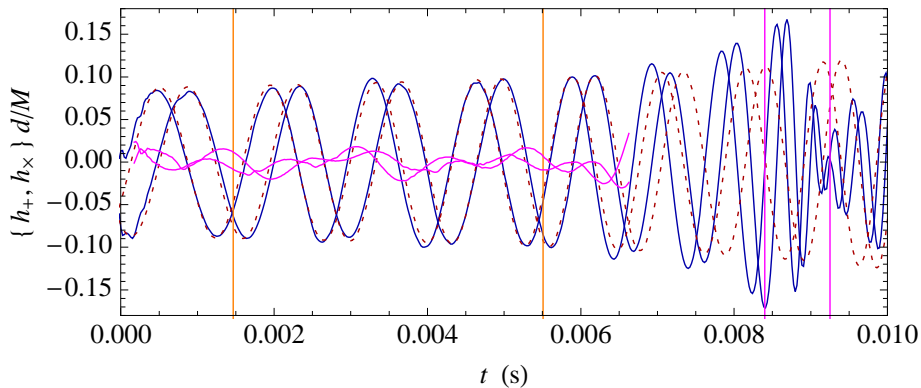
Resulting waveforms for soft, medium, and stiff EOS



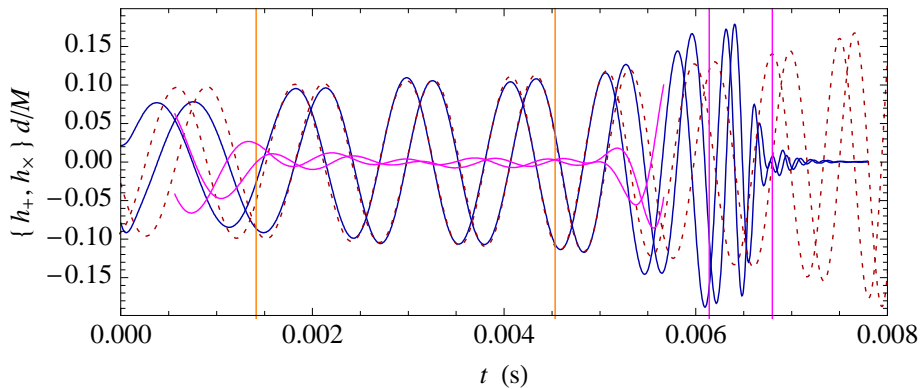
PN matching: stiff EOS



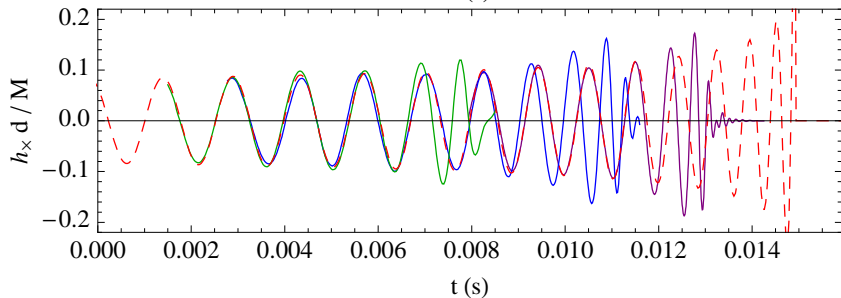
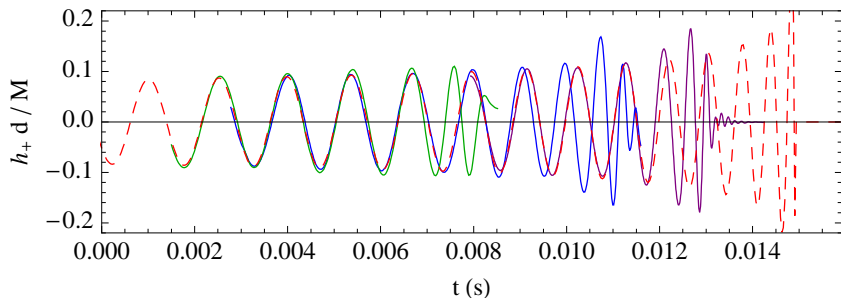
PN matching: medium EOS



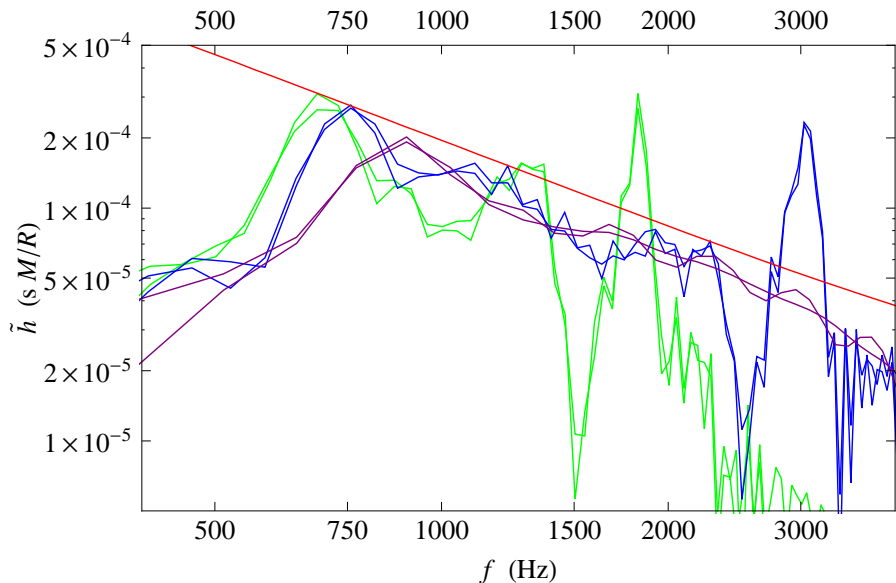
PN matching: soft EOS



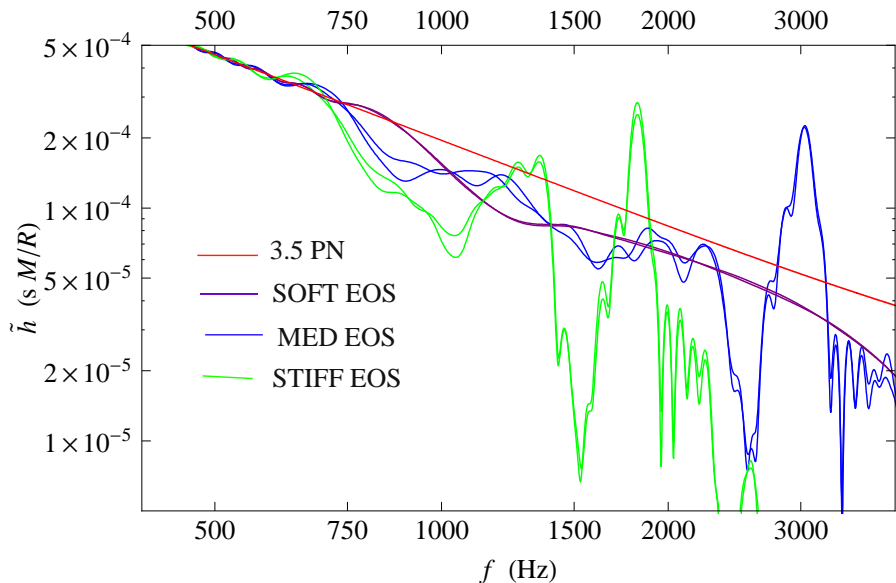
Resulting waveforms for soft, medium, and stiff EOS



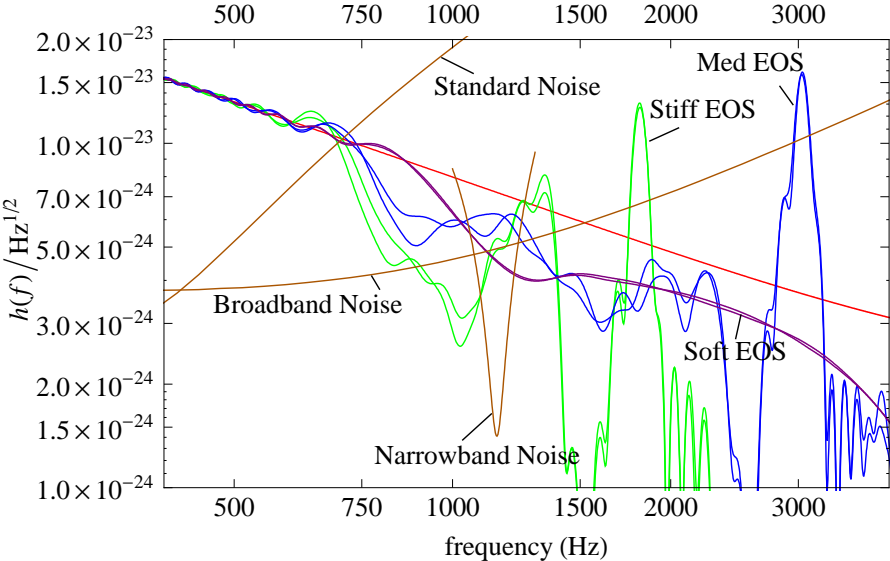
DFT of raw numerical waveform; point particle waveform



DFT of point particle merged with numerical waveform

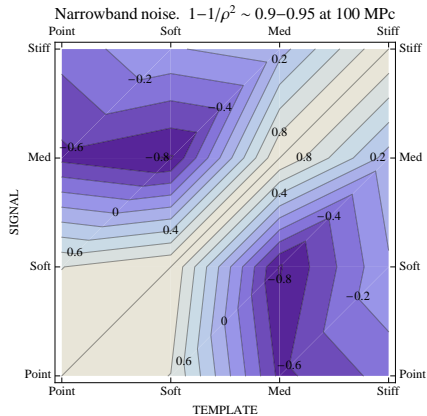
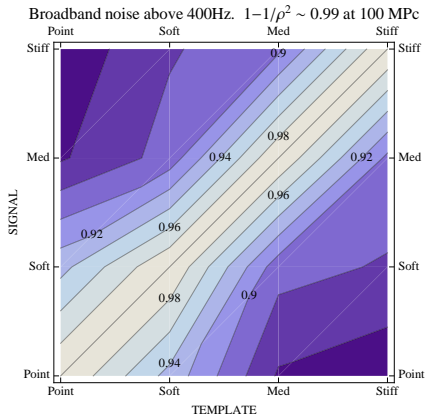


Equivalent Strain Noise

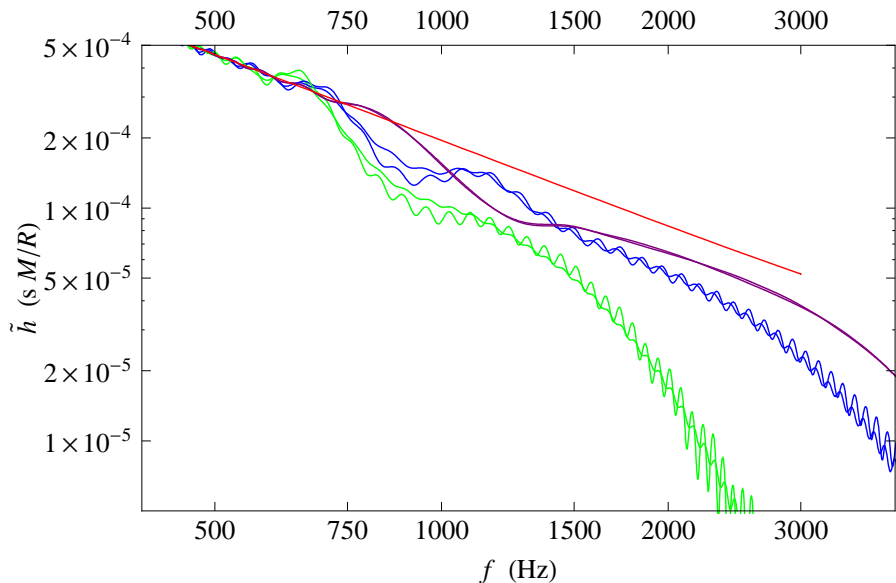


Optimally oriented, 100 Mpc

Match



DFT of waveform up to merger: inspiral only



First order tidal corrections to Post-Newtonian

