Inspiral of comparable mass binaries

Facilitators: Bala Iyer, Thomas Baumgarte, Jolien Creighton

and

NS-NS/NS-BH binary merger

Facilitators: Fred Rasio, Masaru Shibata, Ben Owen

Jolien Creighton

University of Wisconsin – Milwaukee

LIGO-G020379-00-Z

Source working groups

Inspiral of comparable mass binaries

The late stages of inspiral, up to the final plunge and merger, for BH/BH, NS/BH, and NS/NS binaries, including spin-induced precession. Source analysis currently being carried out via post-Newtonian methods, resummation methods (Pade approximates, effective one-body), and numerical relativity methods (with helical killing vector field, and/or conformally flat space slices, and/or standing-wave boundary conditions). Data analysis currently via matched filters using post-Newtonian or kludged waveforms, and by fast chirp transform.

NS/NS and NS/BH Merger

[LIGO/VIRGO/GEO/TAMA and Bars] For NS/NS binaries: plunge induced by combined GR and tidal couplings; bar formation and evolution; oscillations. For NS/BH: tidal disruption of the NS by the BH. Source analysis is currently by numerical simulations (Newtonian, post-Newtonian, and fully relativistic). Data analysis is currently via various time-frequency techniques.

http://www.lsc-group.phys.uwm.edu/gwawg

Binary inspiral issues

- Precession of orbital plane in NS/BH systems
  - » “Good enough” waveforms
  - » Maximization over sky position and polarization states
- Intermediate Binary Black Hole (IBBH) inspiral phase
  - » Need to compute waveform and initial data for merger
  - » Numerical relativity in corotating frame in adiabatic limit
  - » Effective one-body, P-approx, and other super-PN methods
  - » Spin issues

Precessing binaries

- Signal is (params: ϑ, φ, ψ, Φ_0; m_1, m_2, a & 3 more)

$$s(t) = [A_+^C(t)F_+(\vartheta,\varphi,\psi) + A_\times^C(t)F_\times(\vartheta,\varphi,\psi)]\cos[2\Phi(t) + 2\Phi_0]$$
$$+ [A_+^S(t)F_+(\vartheta,\varphi,\psi) + A_\times^S(t)F_\times(\vartheta,\varphi,\psi)]\sin[2\Phi(t) + 2\Phi_0]$$

- Complex filters are

$$z_+(t) = \left\langle h(t) \middle| [A_+^C(t) + iA_+^S(t)]\exp[i2\Phi(t)] \right\rangle$$
$$z_\times(t) = \left\langle h(t) \middle| [A_\times^C(t) - iA_\times^S(t)]\exp[-i2\Phi(t)] \right\rangle$$

- Maximum likelihood statistic is

$$\rho^2(t) = \Sigma(t)\left(1 + \sqrt{1 - \Delta^2(t)/\Sigma^2(t)}\right)$$

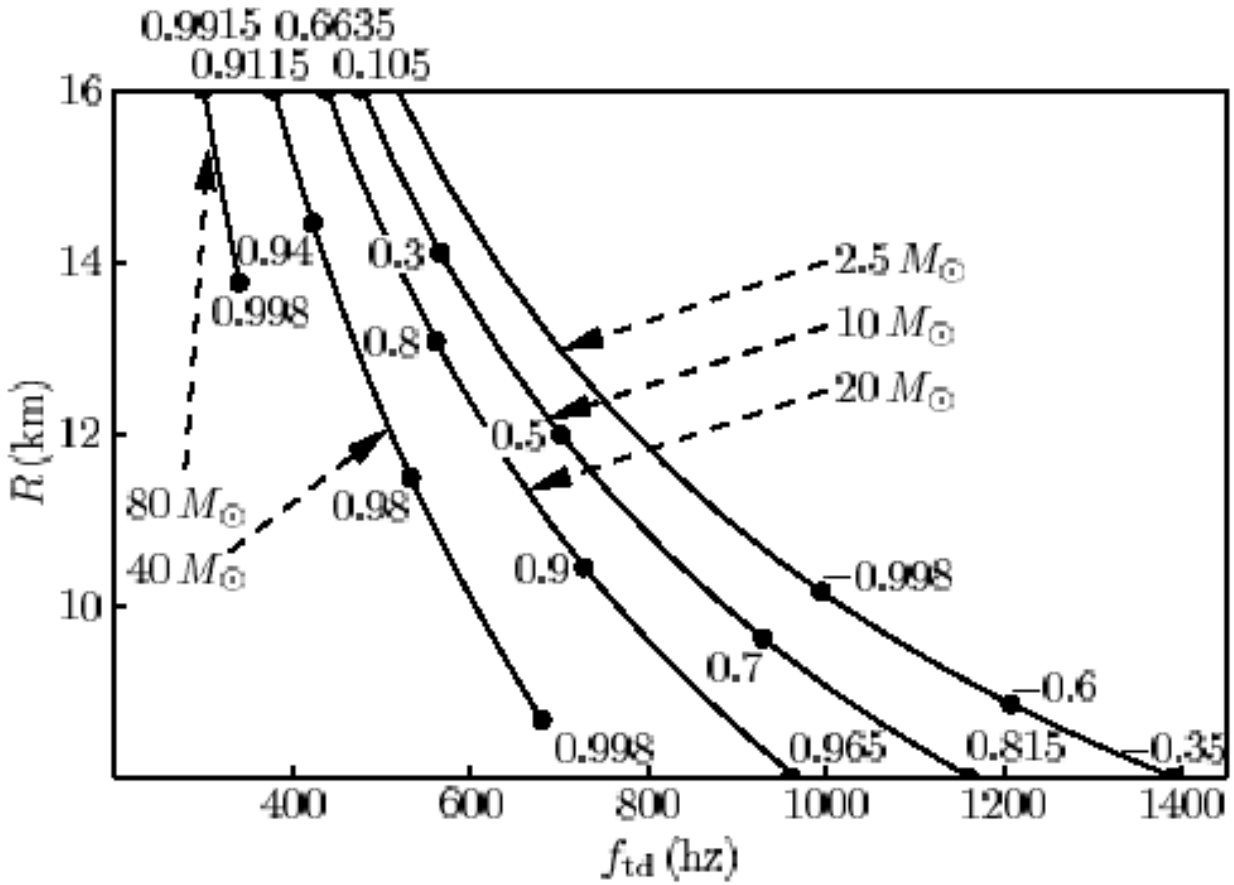
$$\Sigma(t) = |z_+(t)|^2 + |z_\times(t)|^2 \quad \Delta(t) = z_+^*(t)z_\times(t) + z_\times^*(t)z_+(t)$$

NS-NS/NS-BH merger issues

- Plunge/merger waveforms: numerical relativity
  - » Determination of ISCO: Super-PN methods/numerical methods
  - » Computation of merger — what results?
  - » NS binary mergers as γ-ray burst sources
- Tidal disruption of NS in NS-BH systems
  - » Vallisneri, Phys.Rev.Lett. 84 (2000) 3519
- Determination of NS size from finite-size corrections to inspiral
  - » Faber, Grandclement, Rasio, Taniguchi, astro-ph/0204397

Tidal disruption of NS

Vallisneri, Phys.Rev.Lett. 84 (2000) 3519



Finite size effects on NS inspiral