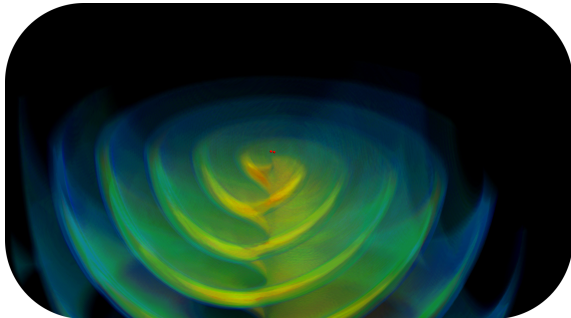


Generic Binary Neutron Stars Systems

Tim Dietrich

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July 11th 2016



BNS parameter space

Parameters:

- Mass M
- Mass ratio q
- Spin \vec{S}^A, \vec{S}^B
- EOS

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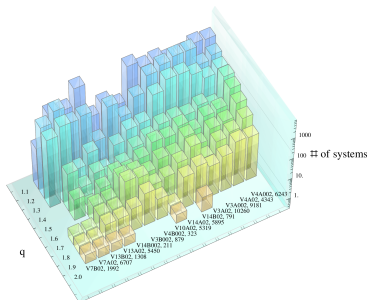
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Mass ratio: most observed BNS have comparable masses around $\sim 1.35M_{\odot}$
in situ models predict mass ratios up to $q \approx 1.8$

\Rightarrow high-mass ratios are possible



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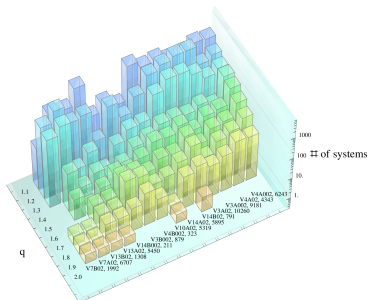
Spin:

single NS observed up to 716Hz

 $(\chi \sim 0.3 - 0.6)$

BNS observed up to 44Hz

⇒ NS are spinning objects



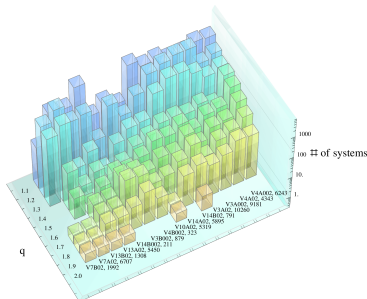
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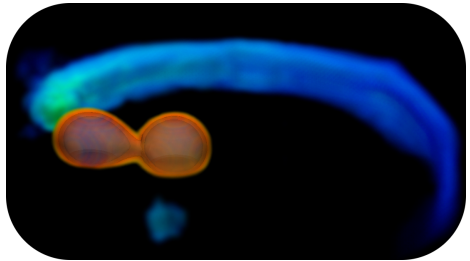
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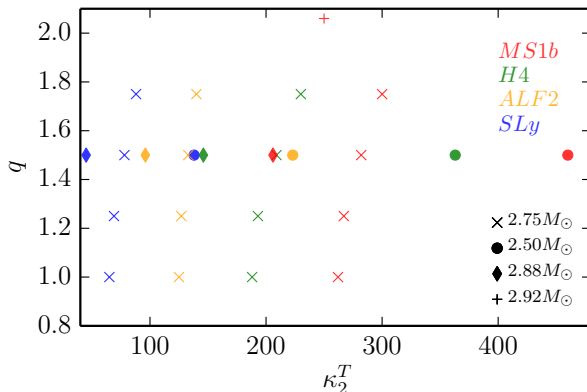
Upgrade of W.Tichy's SGRID code, [Tichy, 2009]

high mass-ratio, eccentric, spinning systems [Dietrich et al, 2015]

Effect of the mass-ratio



Effect of the mass-ratio



- 51 new NR simulations
- varying EOS, mass M , mass ratio q

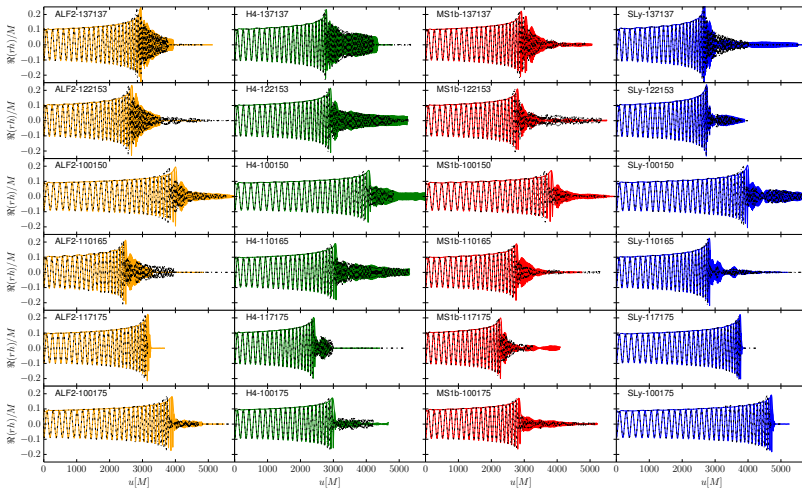
$$q := M_A/M_B$$

$$\kappa_2^T = 2 \left(\frac{q^4}{(1+q)^5} \frac{k_2^A}{C_A^5} + \frac{q}{(1+q)^5} \frac{k_2^B}{C_B^5} \right)$$

Effect of the mass-ratio:GW signal

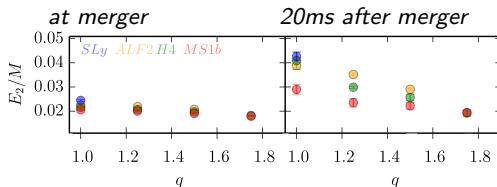
Effect of
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Effect of
the Spin



Effect of the mass-ratio:GW signal

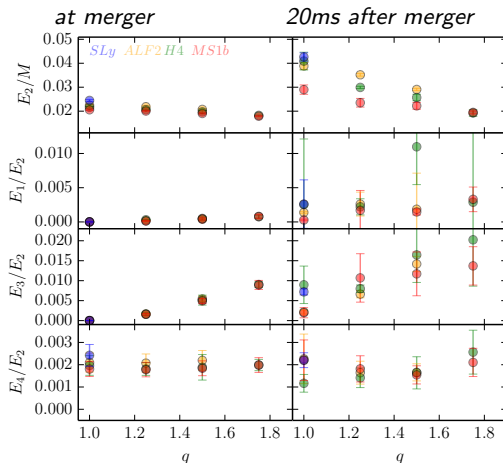
Amount of radiated energy



- released energy decreases for increasing q
- subdominant modes become important for increasing q
- excitation of all modes in postmerger independent of q

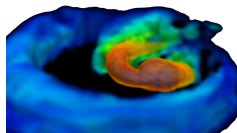
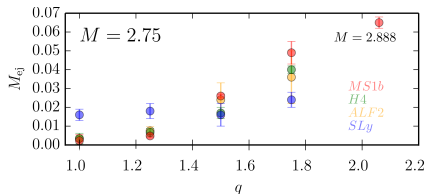
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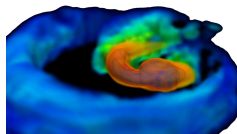
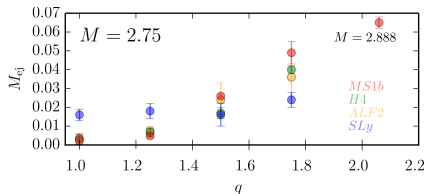
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Effect of the mass-ratio:Ejecta



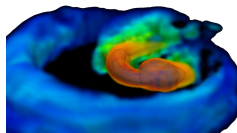
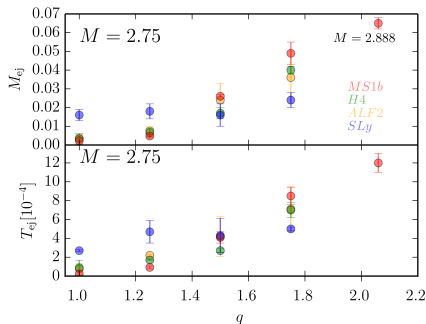
- ejecta mass almost linear in q
- kinetic energy almost linear in q
- ejecta velocity in orbital plane approx. constant
- ejecta velocity perpendicular to orbital plane decreases

Effect of the mass-ratio:Ejecta



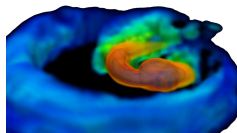
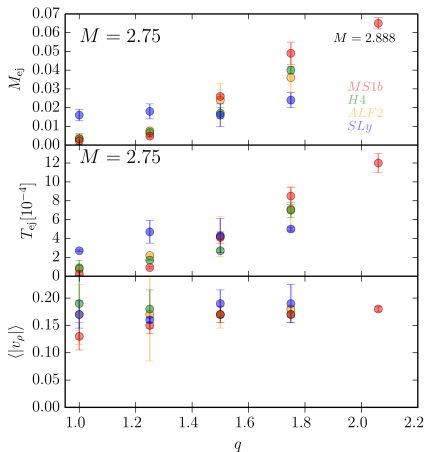
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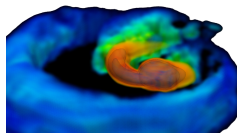
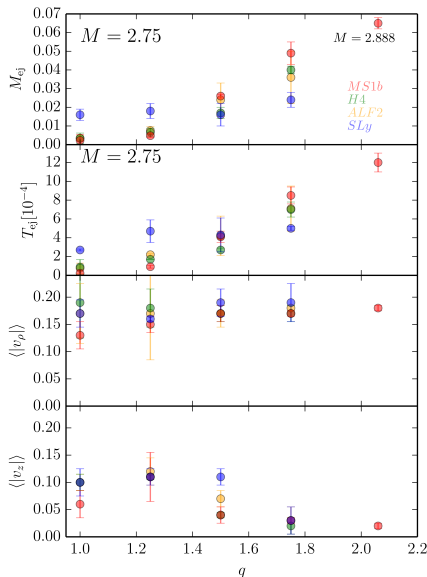
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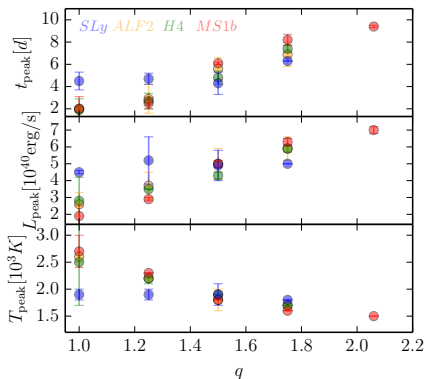
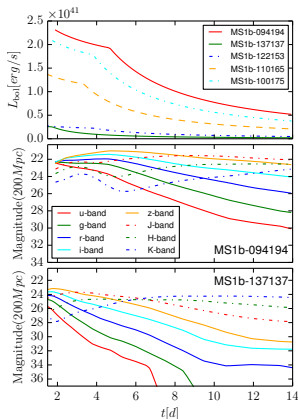
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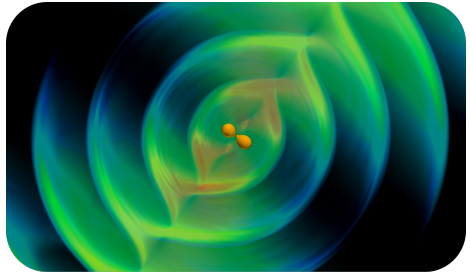
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Effect of the mass-ratio: EM counterparts



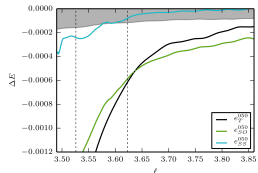
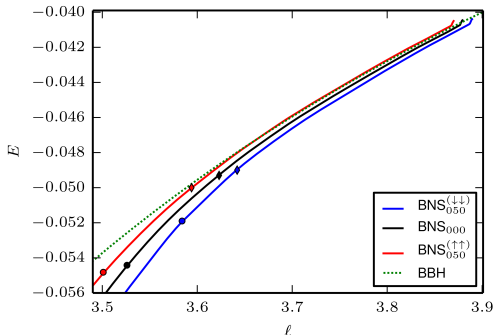
- unequal mass ratios more luminous
- peak luminosity at later times for large q
- temperature at peak smaller for large q
- ejecta velocity perpendicular to orbital plane decreases

Effect of the Spin



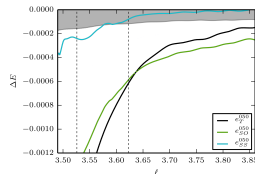
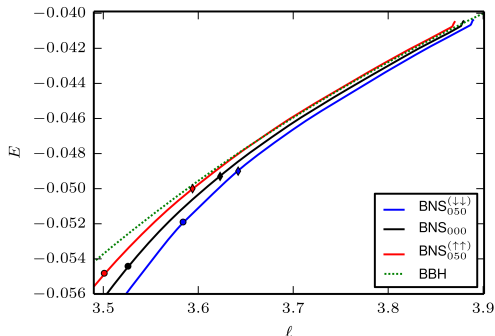
Effect of the Spin

first $E(\ell)$ comparison of BNS/BBH dynamics [Bernuzzi et al, 2013]
 E ... binding energy ℓ .. specific orbital angular momentum



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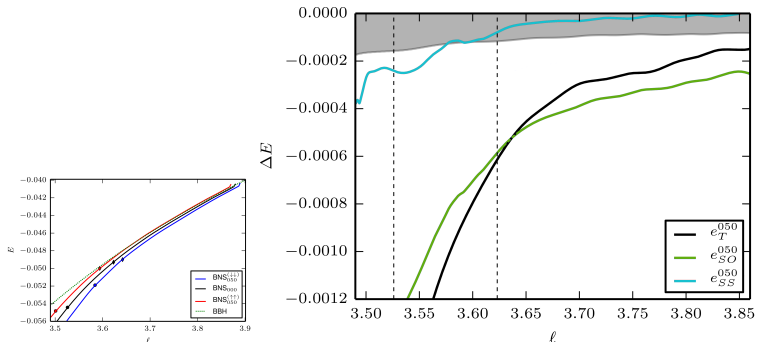


$$E \approx \underbrace{e_0}_{\text{point particle}} + \underbrace{e_T}_{\text{tidal}} + \underbrace{e_{SO}}_{\text{spin-orbit}} + \underbrace{e_{SS}}_{\text{spin-spin}}$$

Effect of the Spin

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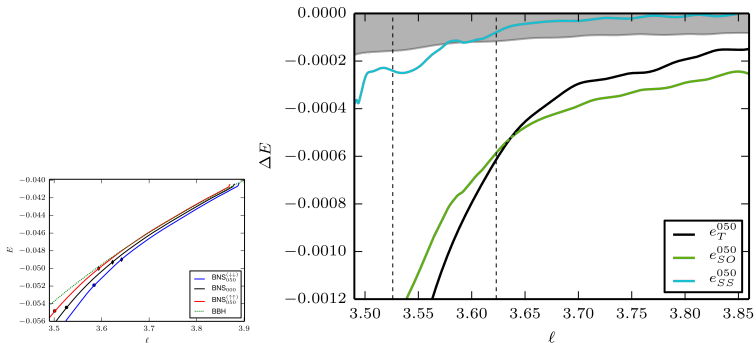
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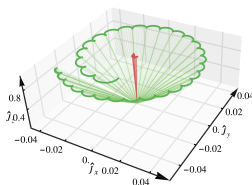
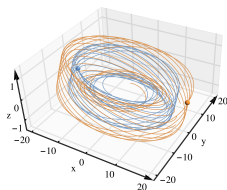
\Rightarrow for $\chi \sim 0.05$ **spin-orbit-term dominant** until contact

\Rightarrow spins **have to** be included for modeling binary pulsar systems

Effect of the Spin: Precession

$M_A = 1.35M_\odot$ and $M_B = 1.11M_\odot$ for SLy-EOS

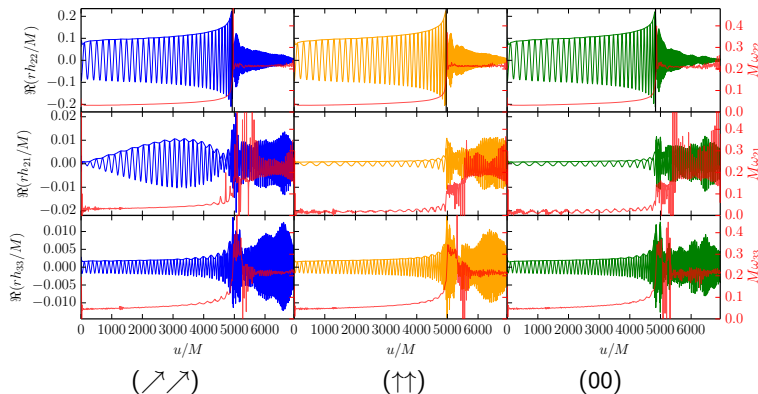
	j_A	j_B
$(\nearrow \nearrow)$	0.13	0.16
$(\uparrow \uparrow)$	0.08	0.09
(00)	0.00	0.00



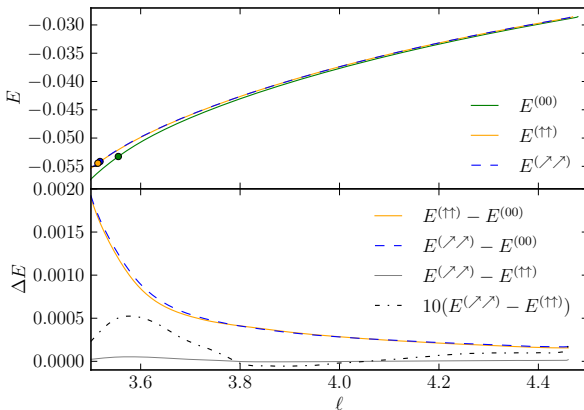
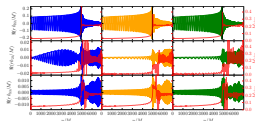
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Effect of the Spin: Precession



$E...$ binding energy

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Summary

- Improvements in the construction of our initial data
- large parameter space study regarding q
 - ejecta mass and luminosity increase for large q
 - GW energy decreases for large q
- first precessing BNS merger
 - influence of precession small compared to spin-orbit effect