Exploring Use of NR Waveforms in Burst Analyses of BBH Mergers

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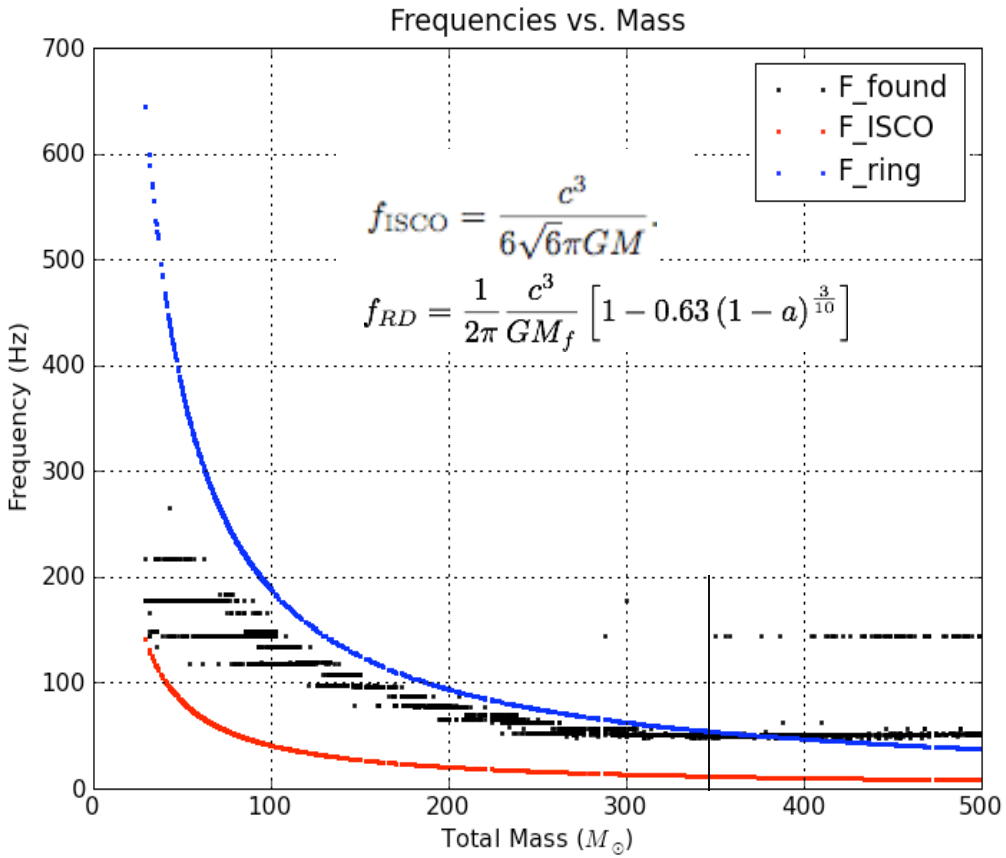
- Systematic study of how the parameters affect detectability and parameter estimation in a burst search - where merger and ringdown yield most SNR in ground-based detectors.
- This is a work in progress: we have set up the infrastructure and are laying out the parameter space we want to explore.
- Initial tests performed with waveforms previously published -- new runs in the works!
- Currently testing detectability of mergers in simulated gaussian noise at the initial LIGO design sensitivity, with SNR 5.5 and the Omega burst search algorithm developed in the LSC. *

*https://geco.phys.columbia.edu/omega

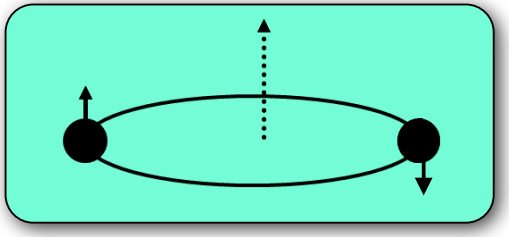
Burst searches

- LSC burst searches look for gravitational wave transients without assumption on the waveform morphology.
- In these searches, NR waveforms are used as simulated signal, not as matched filter template.
- We are testing the impact of different parameters using the Omega algorithm, used by the LSC for burst searches and simulated data.
- Chosen mass range is **80-350M$_\odot$**



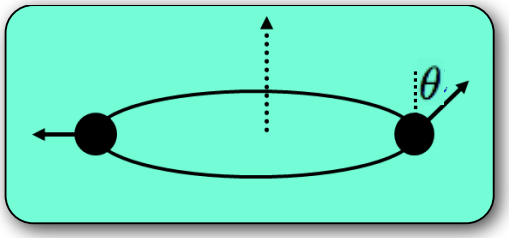
Numerical Relativity Waveforms with MayaKranc (GT)

Anti-aligned spins, equal mass, circular orbit



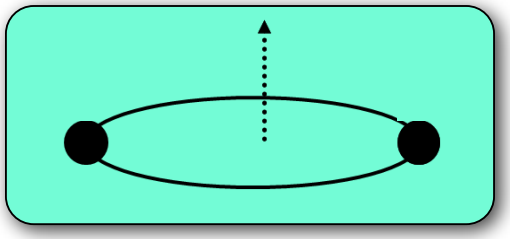
Runs: Herrmann, Hinder, Shoemaker, Laguna, Matzner PRD 2007

Mis-aligned spins, equal mass, quasi-circular orbit



Old Runs: Herrmann, Hinder, Shoemaker, Laguna, Matzner PRD 2007
New Runs: James Healy, 2009

Non-spinning, equal mass, eccentric orbit

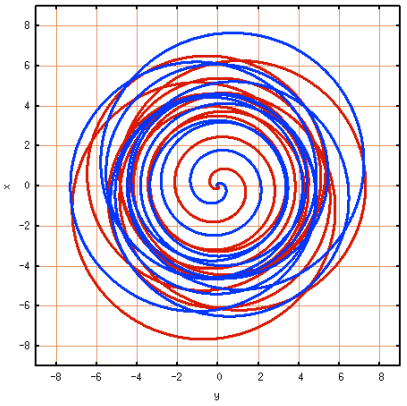


Runs: Hinder, Herrmann Shoemaker, Laguna PRD 2008

Burst Analysis: Eccentric Case

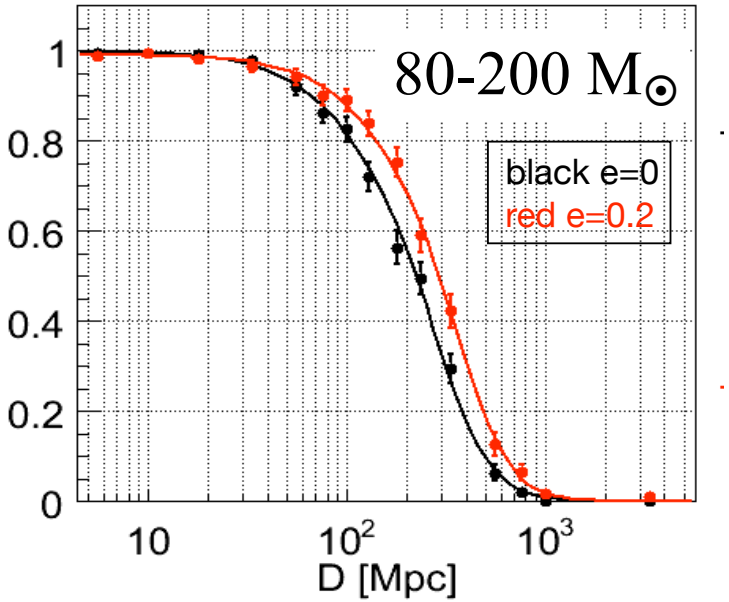
LIGO-DCC G0900029

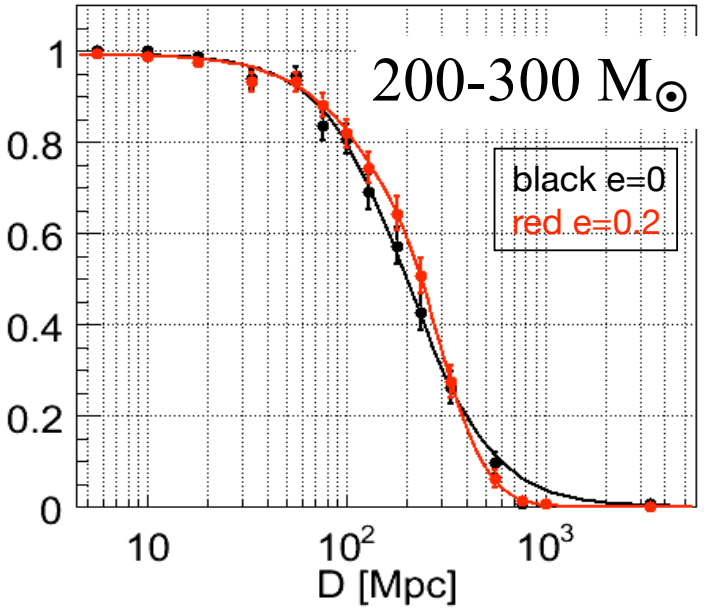
https://dcc.ligo.org/DocDB/0000/G0900029/001/GWDAW13-NR-Burst.pdf



Preliminary Conclusion: Starting to see some differences - too early to conclude.

Fraction Signals Detected at SNR 5.5





Sebastian Fischetti

# waveform	D_50
e=0.0 80-200 Mo	224.02+/-6.56
e=0.2 80-200 Mo	294.90+/-9.01

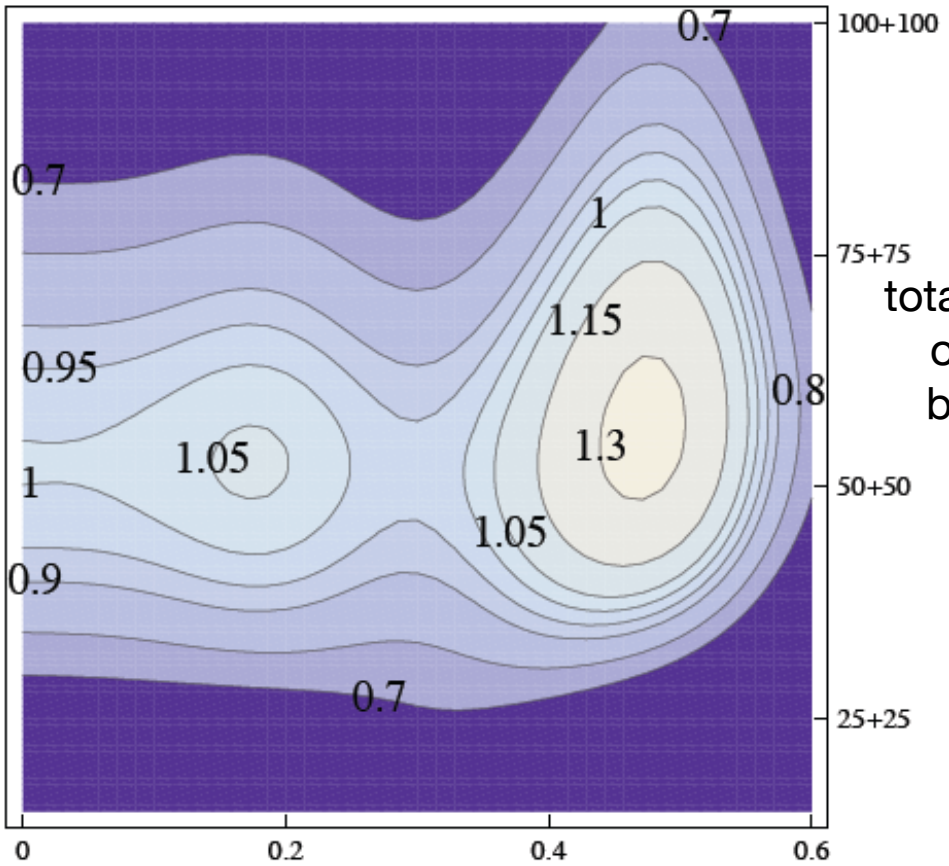
# waveform	D_50
e=0.0 200-300 Mo	201.39+/-7.50
e=0.2 200-300 Mo	238.21+/-7.26

Signal to noise ratio from waveforms of eccentric binaries with initial LIGO noise curve

$$SNR = \langle h(f) \mid h(f) \rangle$$

h(f): one of a range of numerical, eccentric waveforms

SNR where SNR(e=0)=1



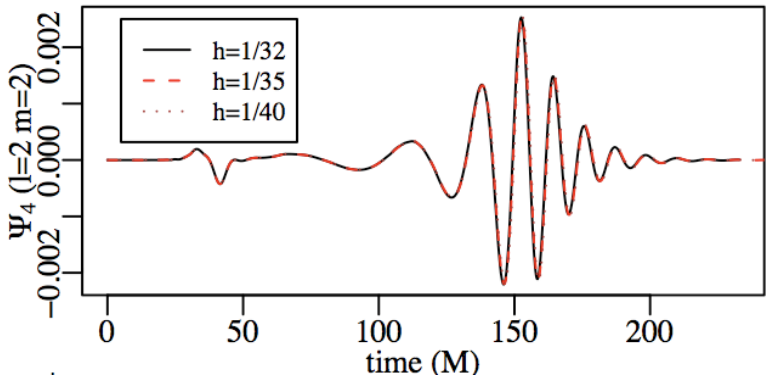
total mass of the binary

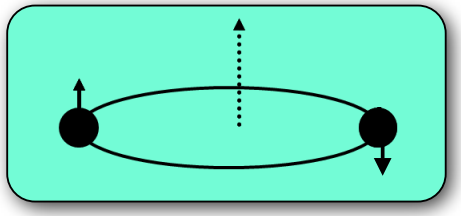
Vaishnav, Hinder, Herrmann, DS
submitted Proceedings GWDAW

Burst Analysis: Spin Case

LIGO-DCC G0900029

https://dcc.ligo.org/DocDB/0000/G0900029/001/GWDAW13-NR-Burst.pdf





Preliminary Conclusions:

- Spin Magnitude does not matter
- Including harmonics l=2,3,4 does not matter

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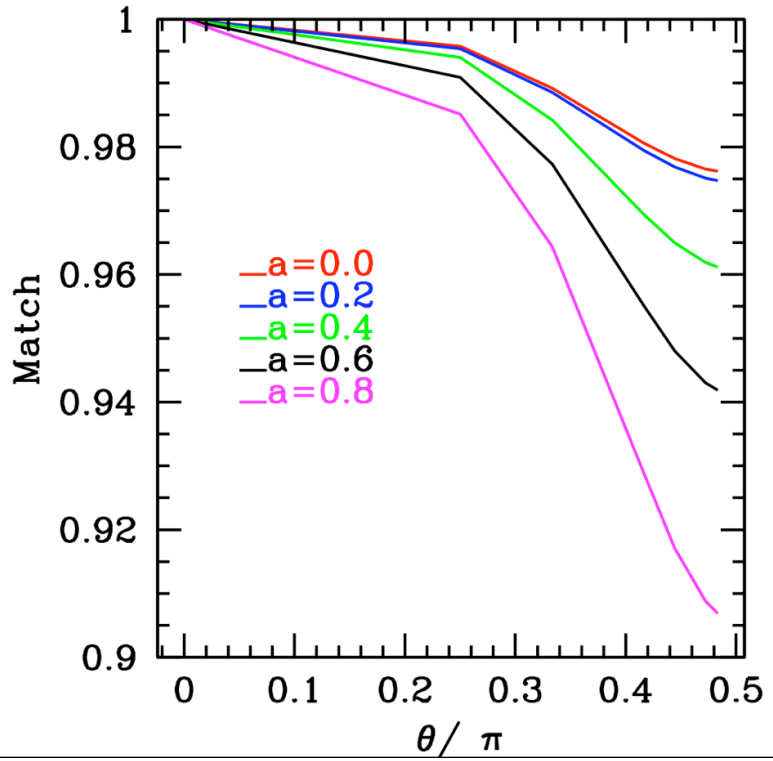
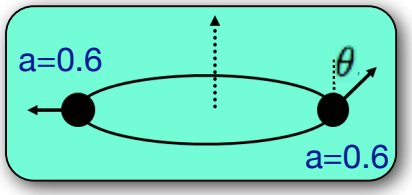
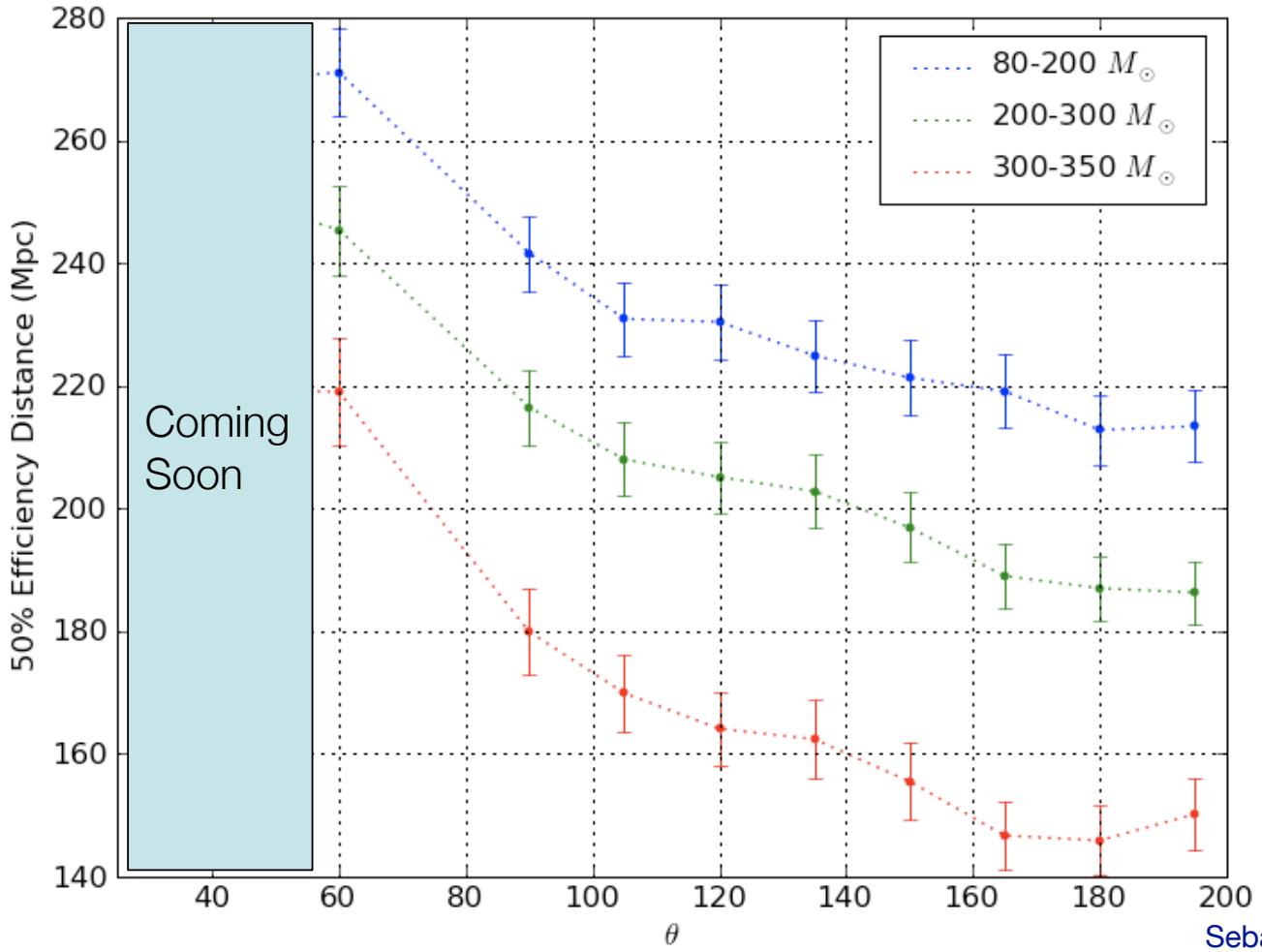


Vaishanv, Hinder, Herrmann, DS PRD2008

Burst Analysis: Mis-aligned Spin Case

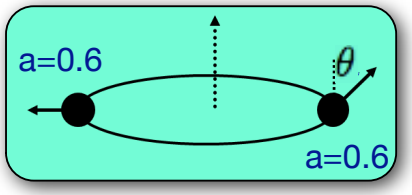


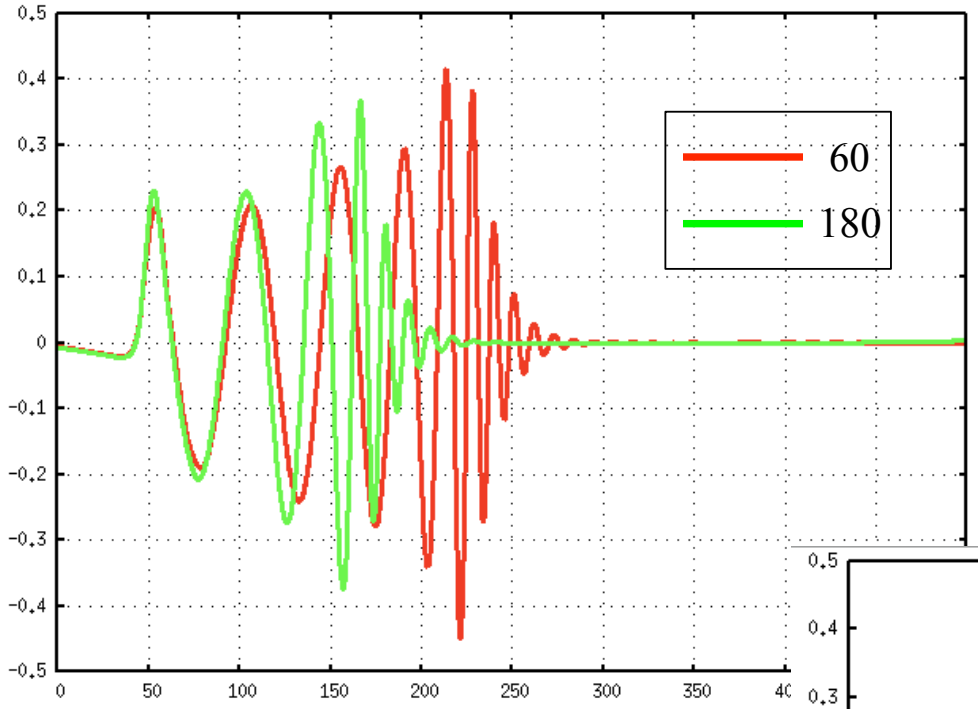
50% Efficiency

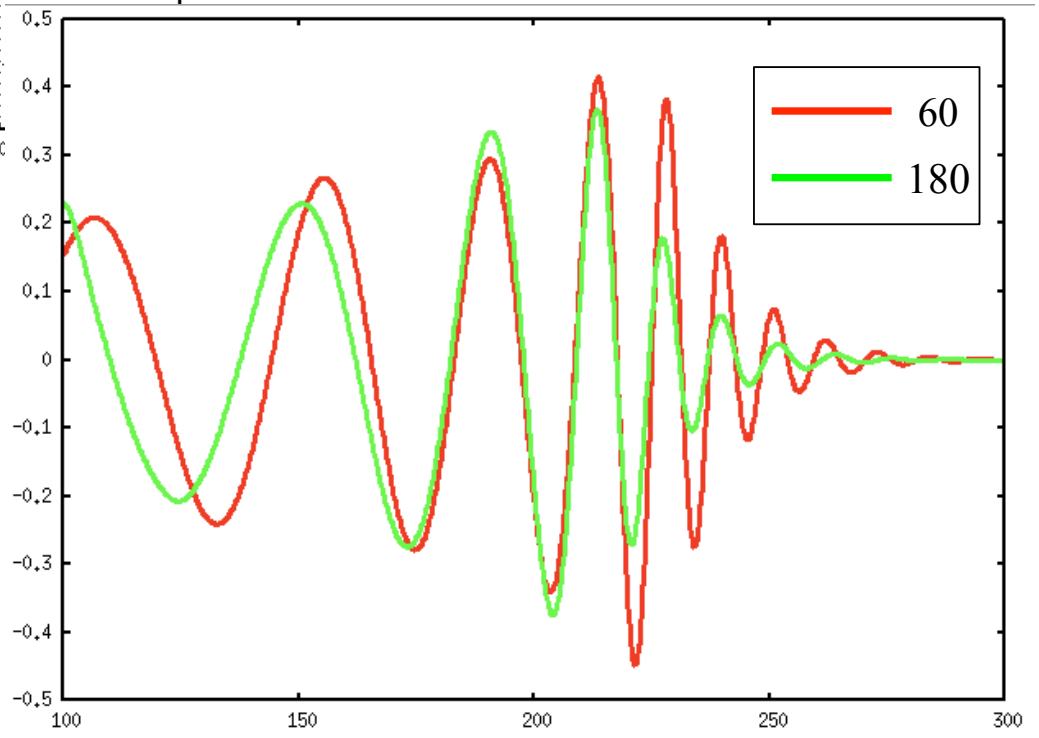


Sebastian Fischetti

Burst Analysis: Mis-aligned Spin Case







Conclusions

- In this ongoing, preliminary study, we found that
  - when the spins were anti-aligned, the NR waveforms were indistinguishable for a burst analysis,
  - when mis-aligned for a=0.6, differences arise in the fraction of signals detected at a chosen distance and SNR; and,
  - the eccentric binaries also show that a greater eccentricity leads to a higher fraction of detected signals.
- The NR waveforms used for this study are currently being improved by adding resolution, extrapolating them to infinity spanning more spin magnitudes, mass ratios