

Third Release of the RIT Gravitational Wave Catalog and Applications

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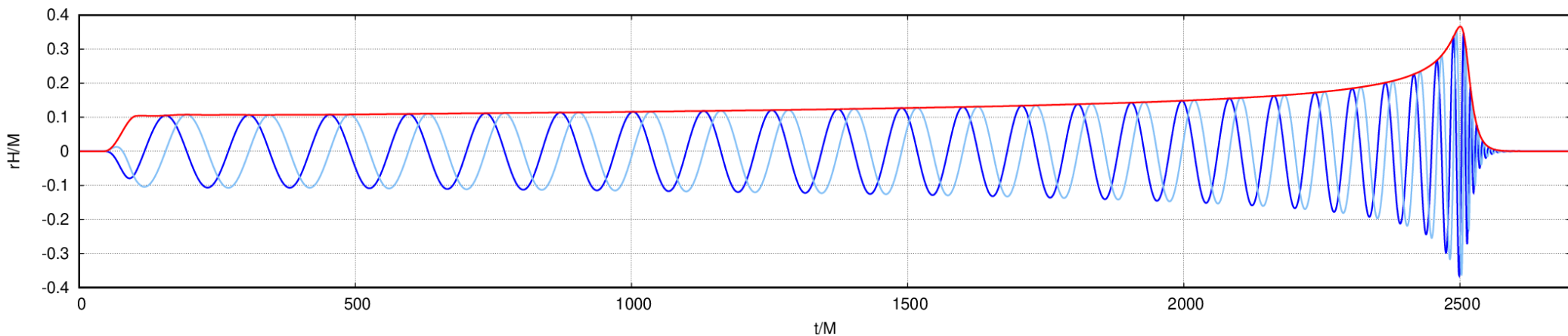
Rochester Institute of Technology

Midwest Relativity Meeting
October 24, 2020

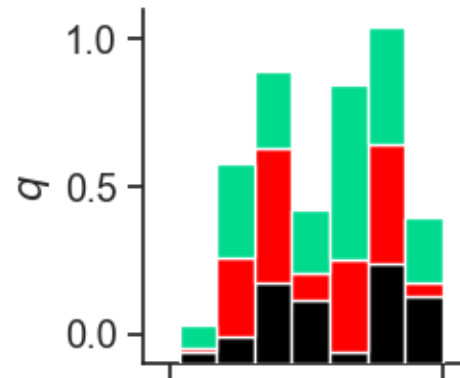
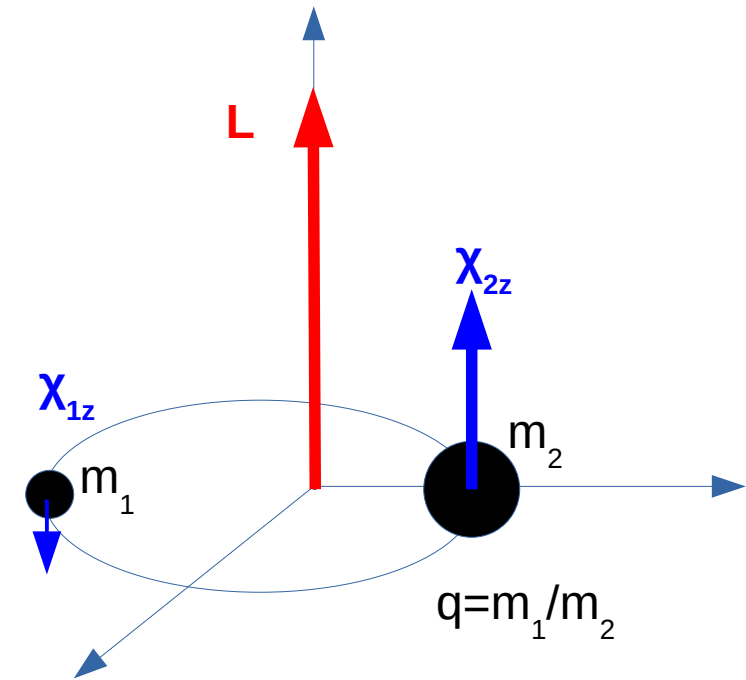


Introduction

- <https://ccrgpages.rit.edu/~RITCatalog>
- 777 waveforms: 477 Aligned, 300 Precessing
- Ψ_4 ASCII tarball & Strain LVCNR hdf5 format
- Center-of-mass correction
- Applications
 - Relationships between final state parameters
 - Parameter estimation of LIGO-VIRGO O1/O2 runs

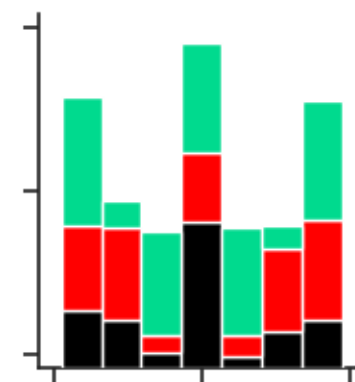
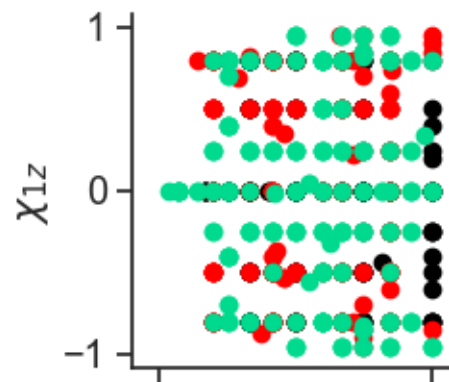


Aligned Systems

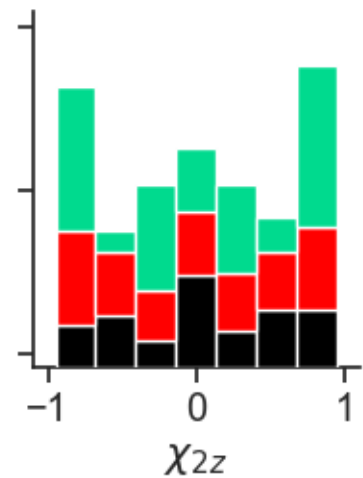
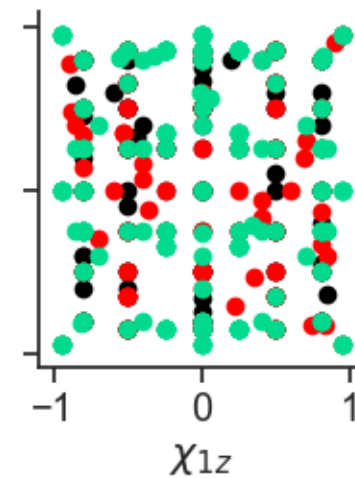
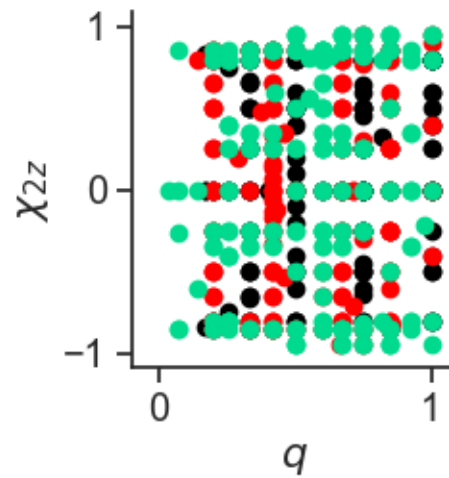


* Lowest mass ratio, $q=1/15$

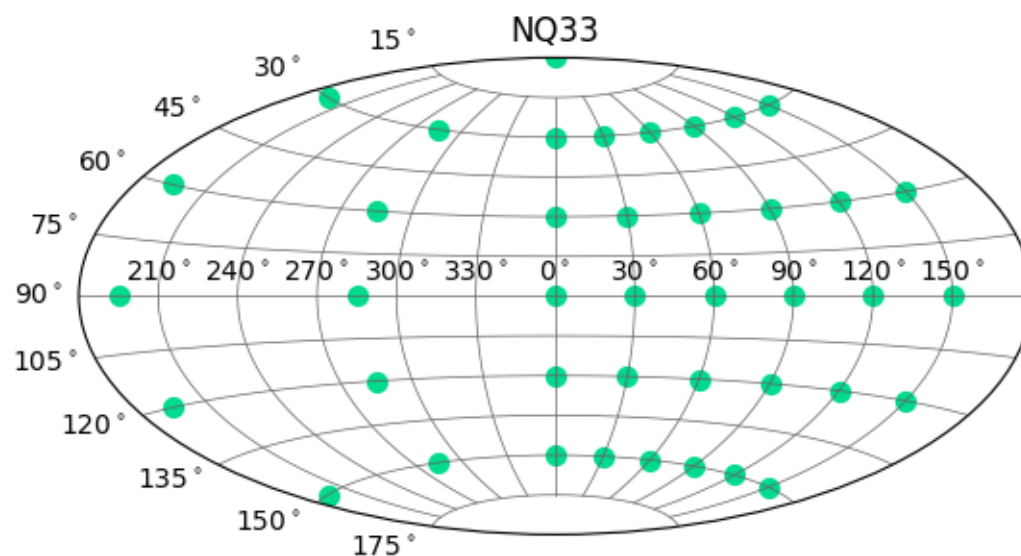
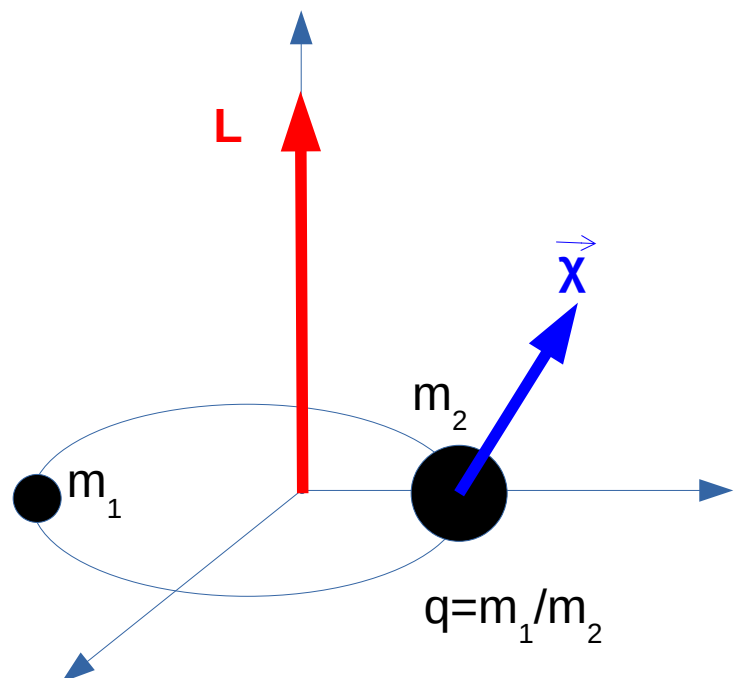
* Spins as high as 0.95 for mass ratios between 0.5 and 1



Catalog 1
Catalog 2
Catalog 3



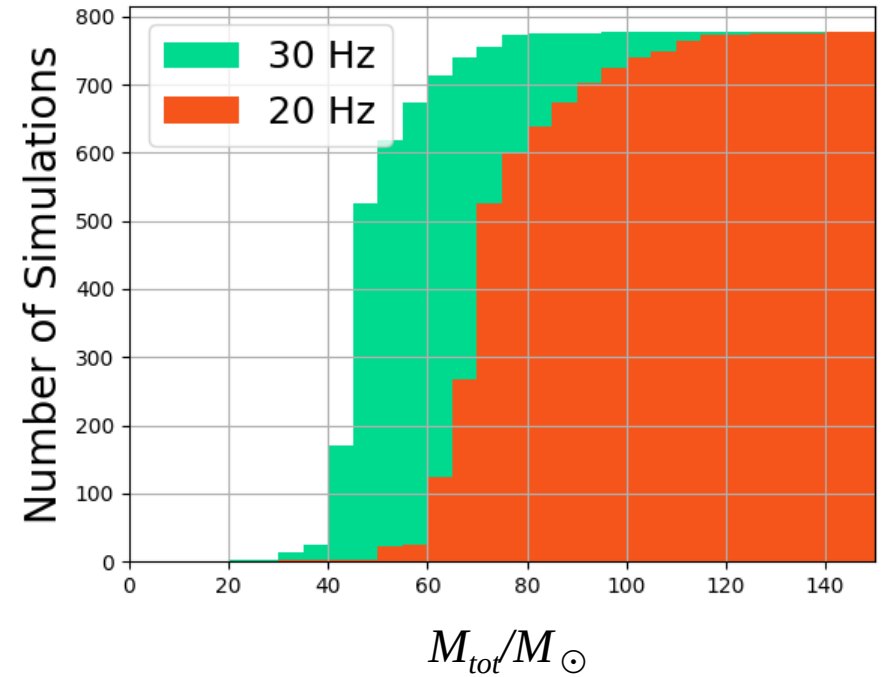
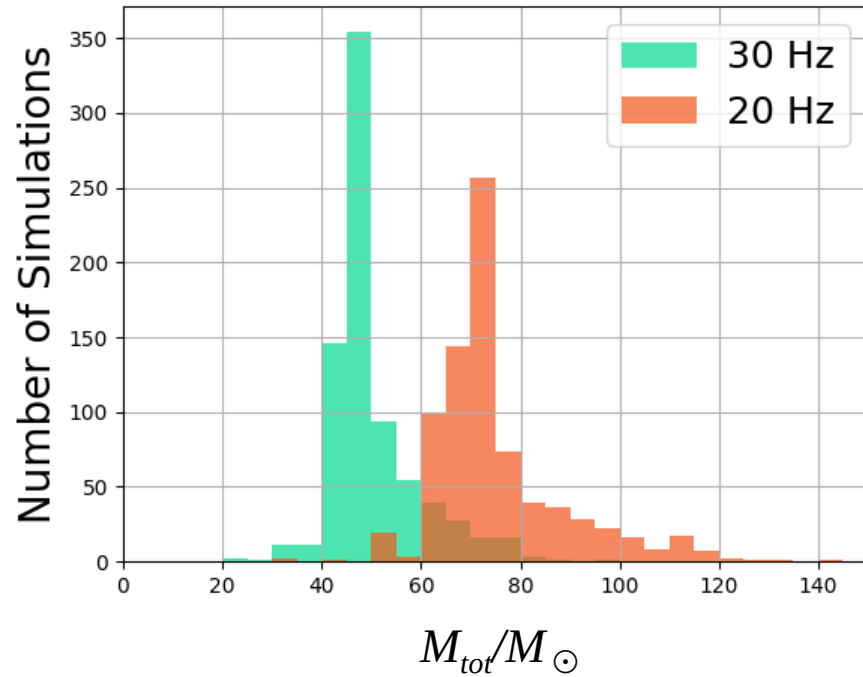
Precessing Systems



- * One BH spinning
- * Either large or small
- * Continuous q :
 - $q < 1$ if large BH is spinning
 - $q > 1$ if small BH is spinning

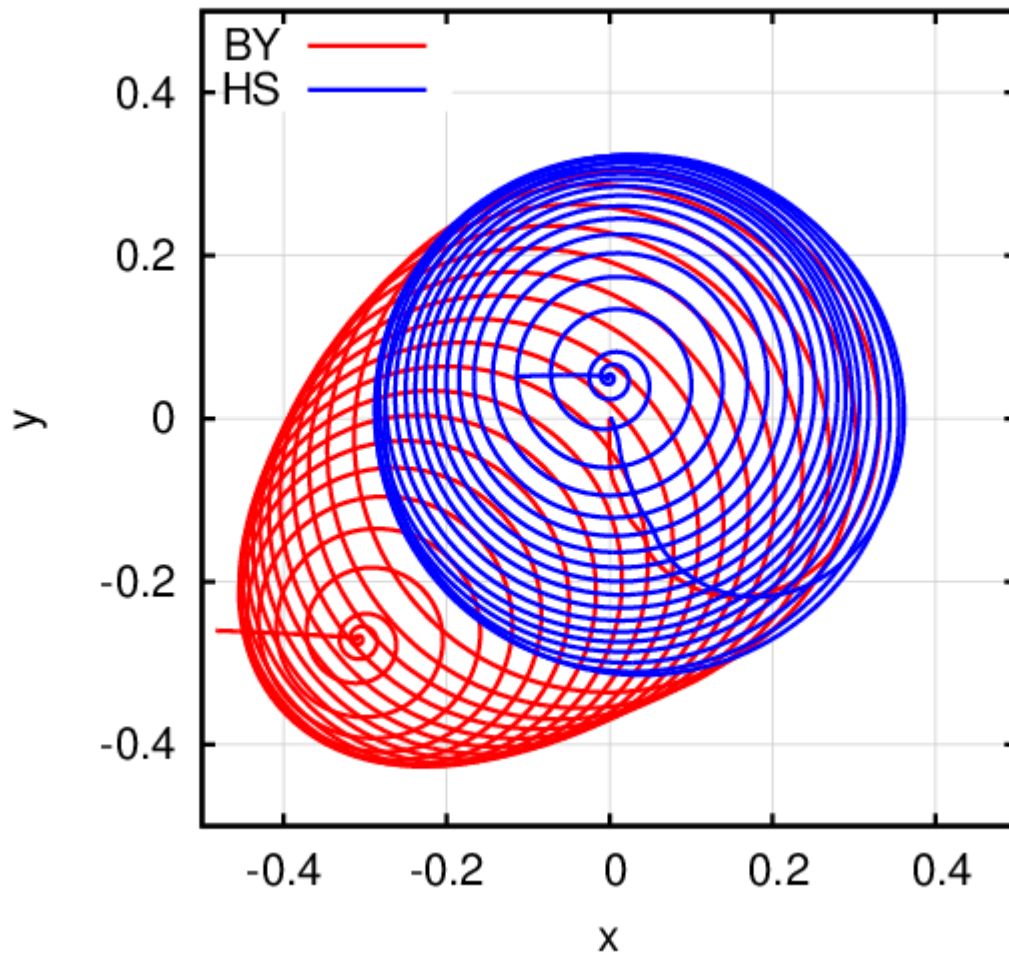
- * Spin magnitude fixed at 0.8
- * Vary spin angles, θ and ϕ
- * Typical coverage for a given q
- * 9 q 's between 0.2 and 2.0

Waveform Duration



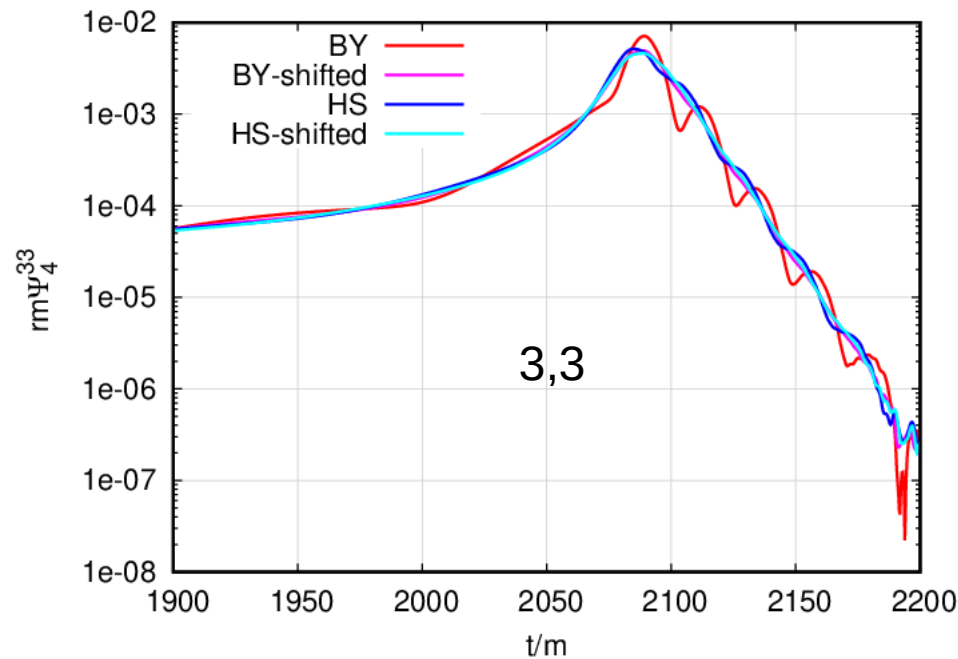
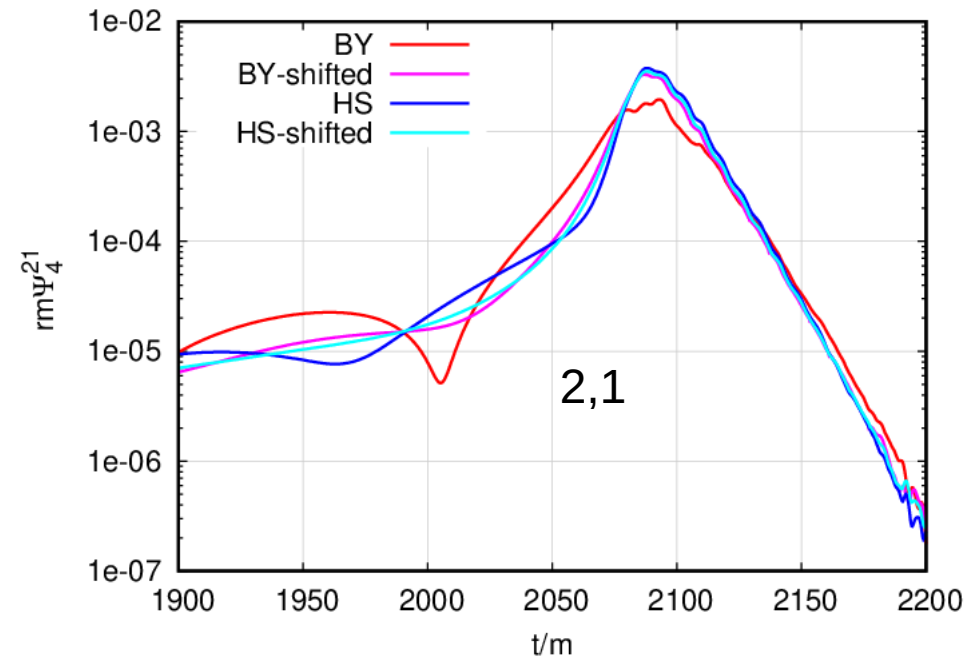
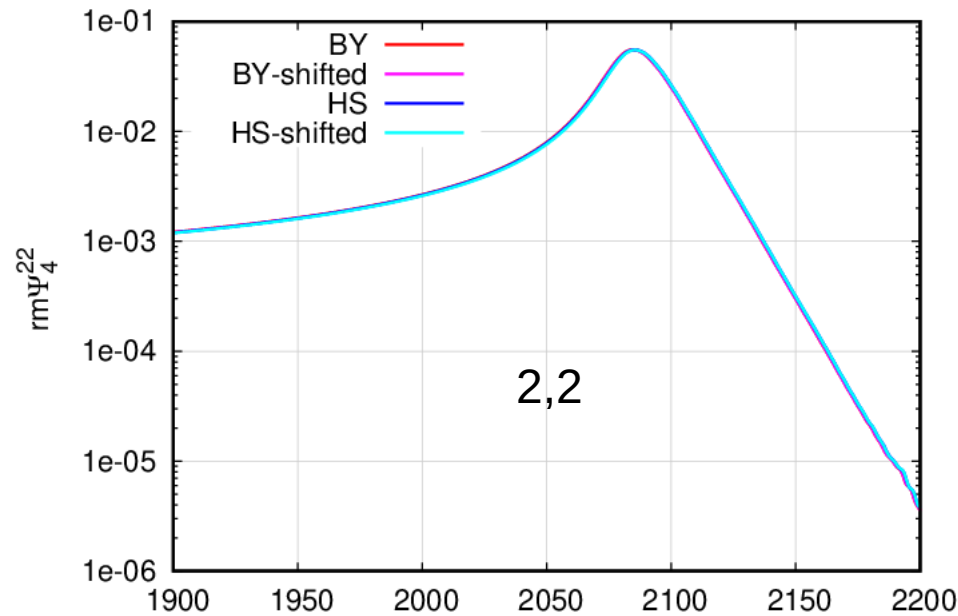
- * Majority of simulations have a starting frequency of 30Hz at 50 M_{\odot}
- * For 20Hz, that increases to 75 M_{\odot}

Center-of-Mass Correction



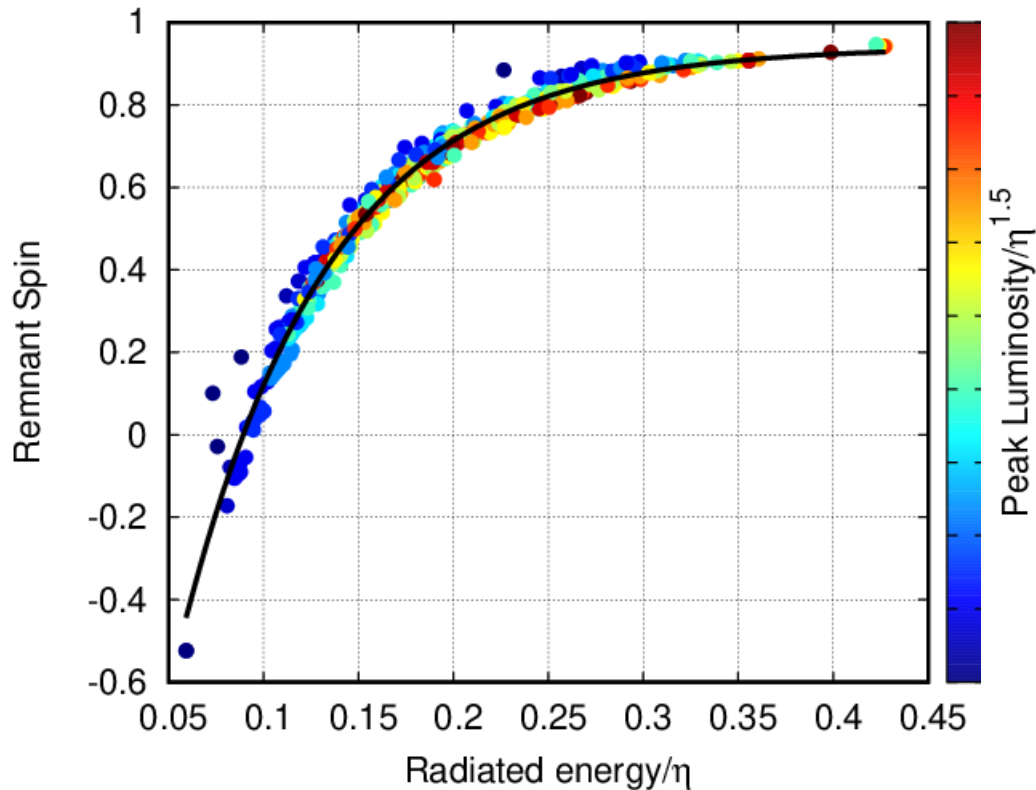
- * Initial data contains some junk radiation
 - * Can impart a recoil velocity to the center of mass
 - * Waveform extraction assumes center-of-mass at the origin
 - * Manifests as oscillations in the modes
-
- * We apply a correction to the individual modes in post-processing

Center-of-Mass Correction

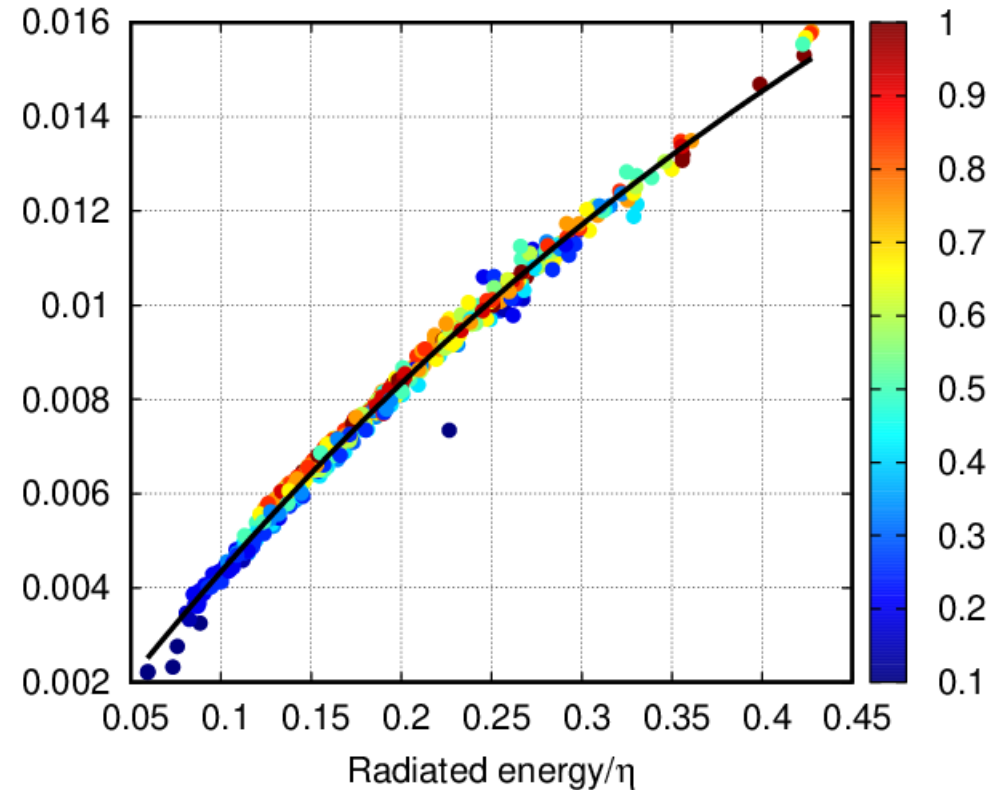


- * BY = Bowen York
- * HS = High Spin Initial Data
(lower junk radiation content)
- * shifted = CoM correction applied
- * 2,2 mode unaffected
- * For higher modes, oscillations are reduced in BY-shifted to HS and HS-shifted levels.

Final State Correlations



$$\alpha_f = 0.940 \pm 0.005 - (2.96 \pm 0.05)e^{(-12.84 \pm 0.19)E_{\text{rad}}/\eta}$$

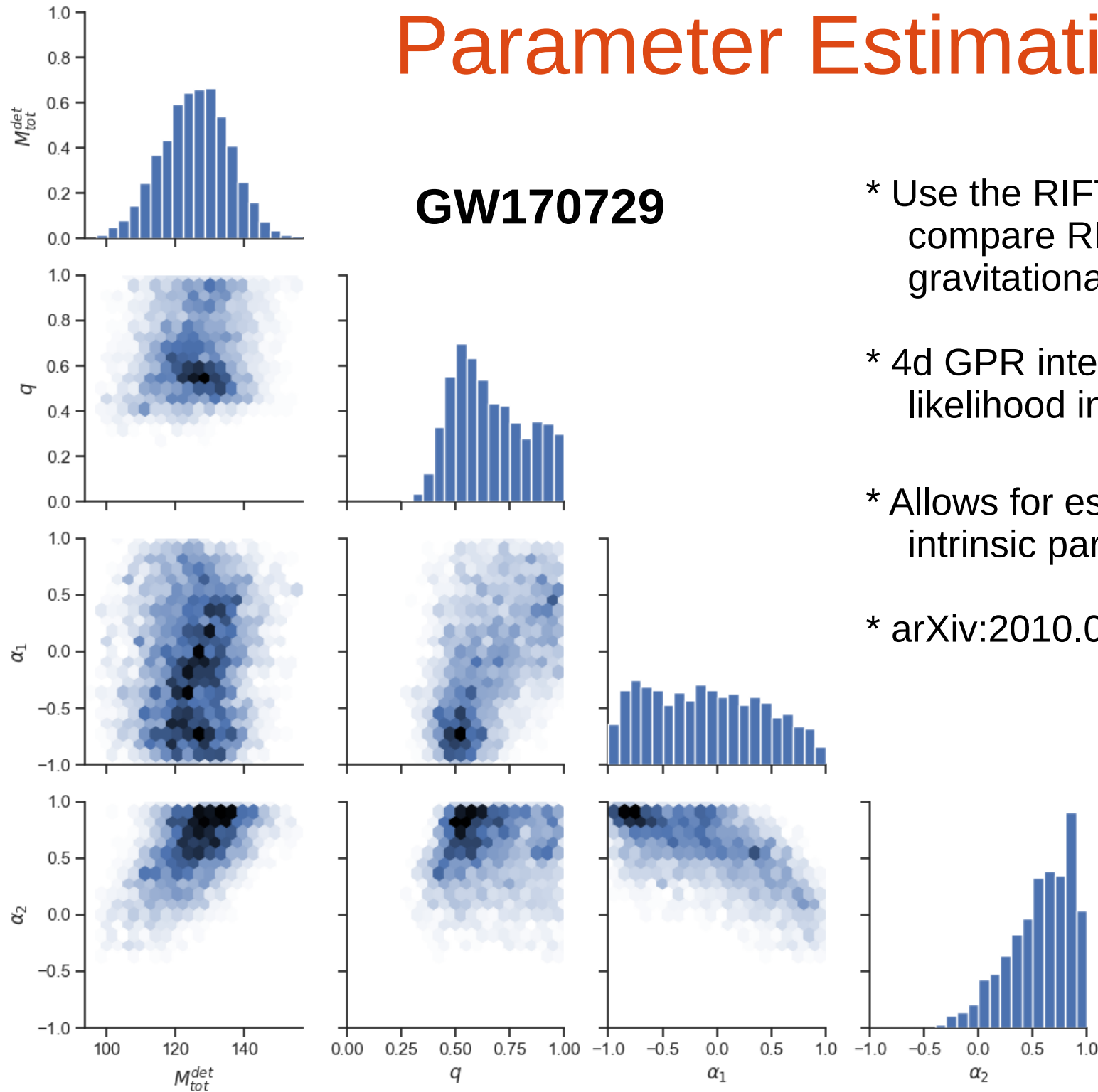


$$L/\eta^{1.5} = 0.030 \pm 0.001 - (0.030 \pm 0.001)e^{(-1.72 \pm 0.09)E_{\text{rad}}/\eta}$$

* Reanalyzed peak radiation and remnant properties in bulk to find simple correlations between quantities

Parameter Estimation

GW170729



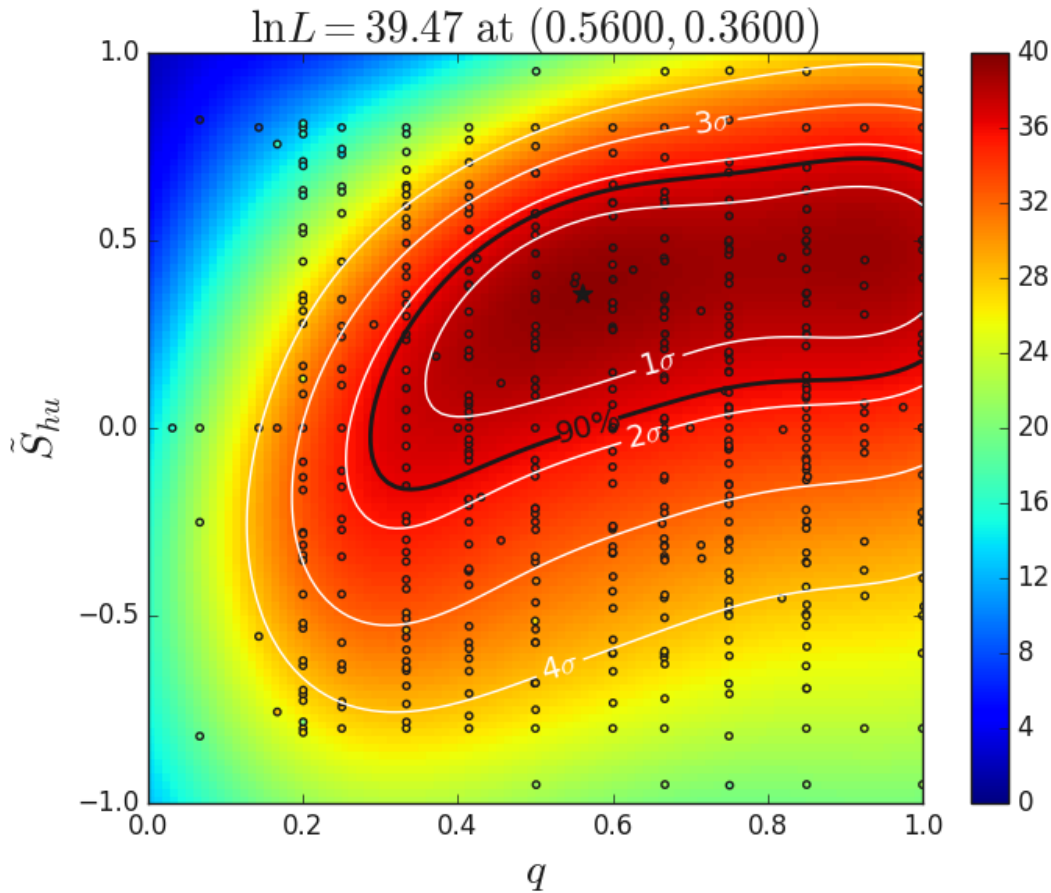
* Use the RIFT code to directly compare RIT Catalog to gravitational wave events

* 4d GPR interpolation of the likelihood in total mass, q , χ_{1z} , χ_{2z}

* Allows for estimation of the intrinsic parameters

* arXiv:2010.00108

On to Catalog 4

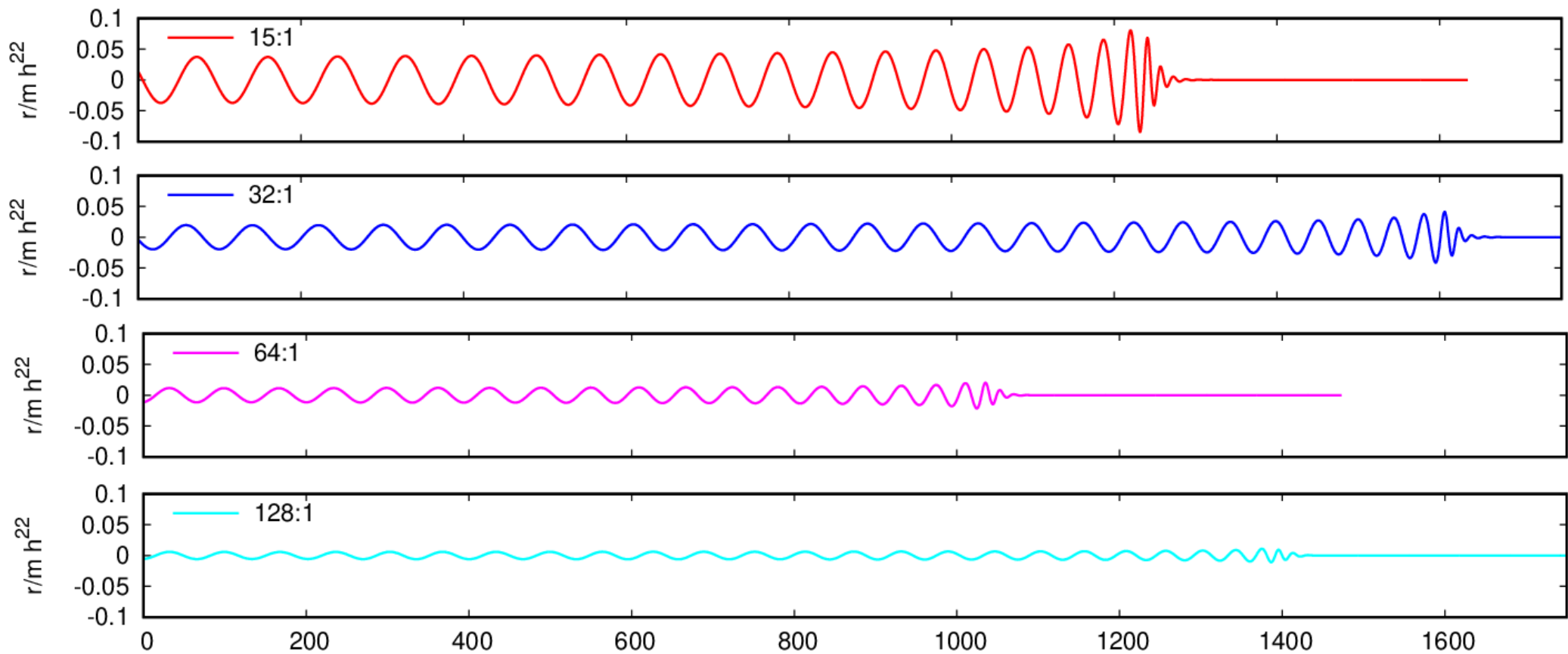


GW170729

- * Small mass ratios, $q < 0.2$
- * High spins
- * Eccentric waveforms

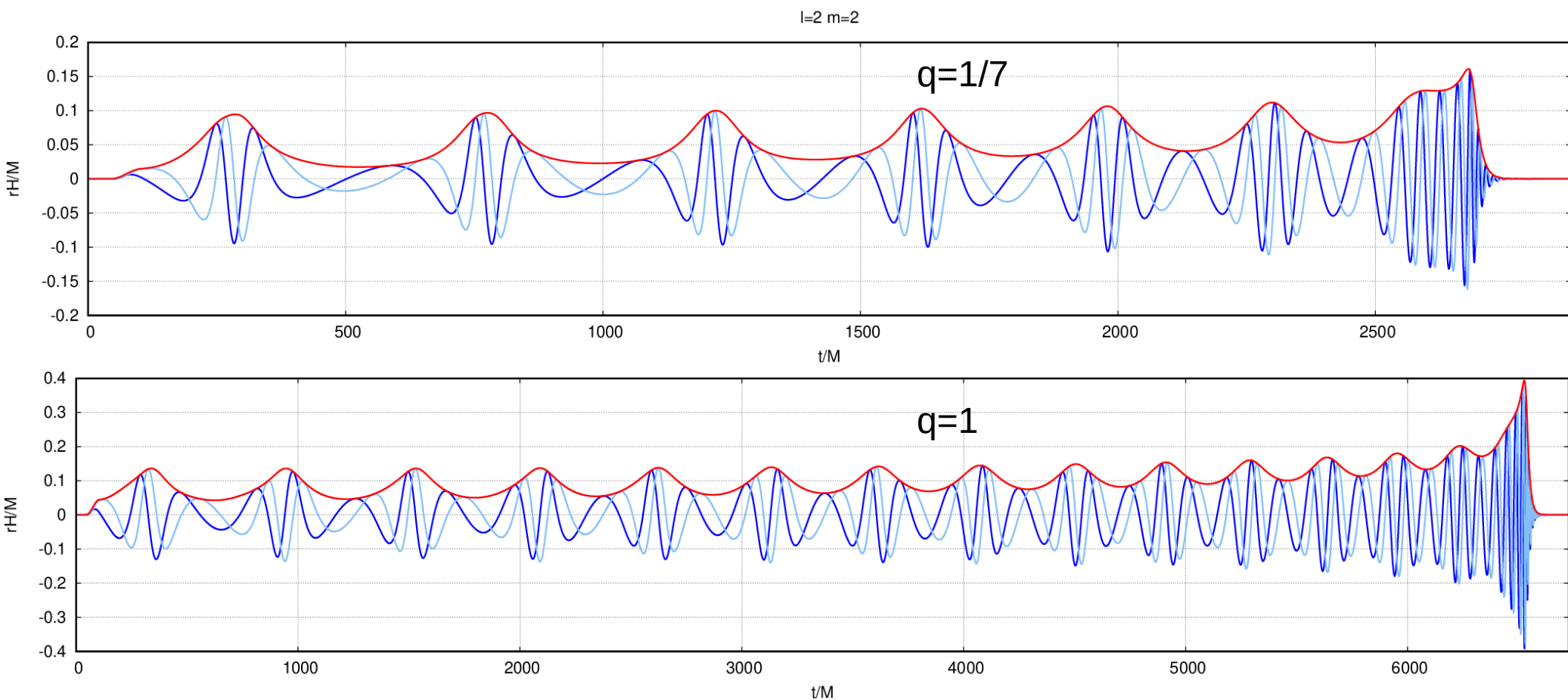
Small Mass Ratios

- * arxiv:2007.07910
- * Nonspinning simulations up to $q = 1/128$
- * Very expensive computationally – Investigating gauge choices and optimizing refinement in time and space



Eccentric Waveforms

* All current catalog simulations have low eccentricity, $e \sim 10^{-3}$



Conclusion

- 777 waveforms in third release of RIT Catalog
- Available to download Ψ_4 and/or Strain
 - <https://ccrgpages.rit.edu/~RITCatalog>
- Applications in bulk analysis and parameter estimation
- Future releases will include small mass ratio systems and eccentric systems