Enhancing Consistency Tests of Relativity

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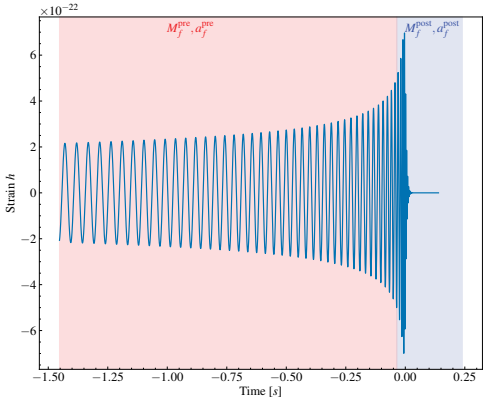
Inspiral-Merger-Ringdown Consistency Tests

- Consistency of the remnant BH mass and spin estimates inferred from the pre- and post-merger signal.
  $\Delta M_f = M_f^{\rm pre} - M_f^{\rm post}$,
  $\Delta \chi_f = \chi_f^{\rm pre} - \chi_f^{\rm post}$.
- Issues with higher order modes, *spectral leakage*, arbitrary choice of cutoff.



Time Domain Likelihood

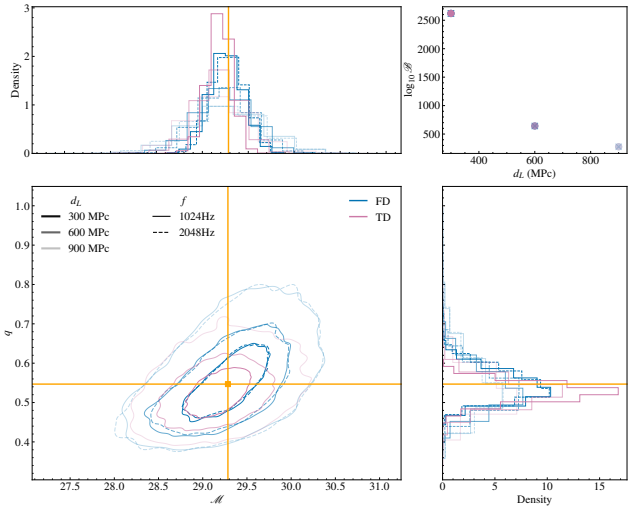
$$\mathcal{L}(\mathbf{d}|\mathbf{h}) = \frac{1}{\sqrt{2\pi \det \mathbf{C}}} \exp\left(-\frac{1}{2}(\mathbf{d}-\mathbf{h})^{\dagger} \cdot \mathbf{C}^{-1} \cdot (\mathbf{d}-\mathbf{h})\right).$$

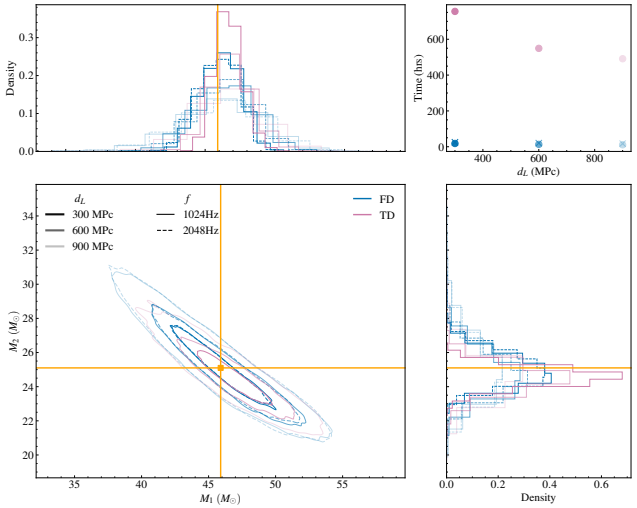
Noise Correlation Matrix $C_{ij} = \langle n_i n_j \rangle$, which adapts a symmetric Toeplitz form for a stationary random process,

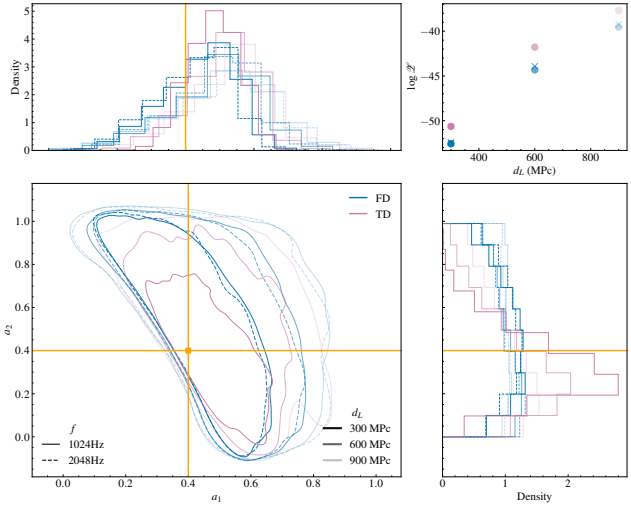
$$C_{ij} = \varrho(|i-j|),$$

where ϱ is the auto correlation function, estimated from the Power spectral density $S_n(f)$ as,

$$\rho(k) = \frac{1}{2T} \sum_{k=0}^{N_{\mathsf{FFT}}-1} S(|f_j|) \exp \frac{2\pi i j k}{N}.$$

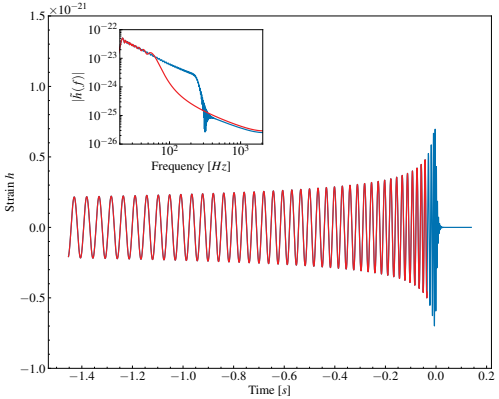

Density
$\log_{10}\mathscr{B}$
d_L (MPc)
d_L
300 MPc
600 MPc
900 MPc
f
1024Hz
2048Hz
FD
TD
q
$\mathscr{M}$
Density


Density
Time (hrs)
d_L (MPc)
d_L
300 MPc
600 MPc
900 MPc
f
1024Hz
2048Hz
FD
TD
M_2 ($M_\odot$)
M_1 ($M_\odot$)
Density


Density
log $\mathscr{L}$
d_L (MPc)
FD
TD
a_2
a_1
f
1024Hz
2048Hz
d_L
300 MPc
600 MPc
900 MPc
Density

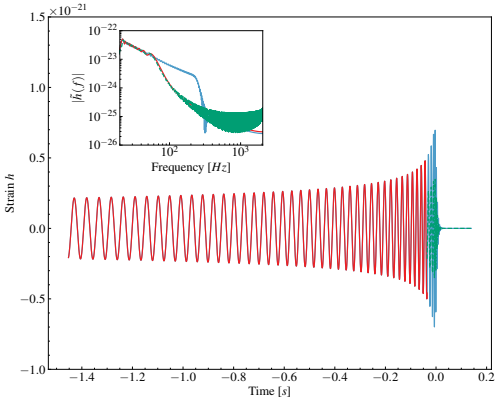
Gating

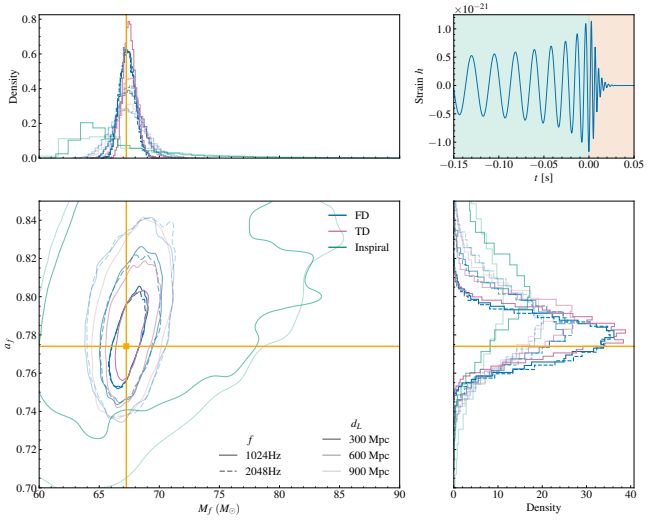
- Spectral Contamination.
- Covariance matrix of truncated noise is no longer Toeplitz.



Equivalence by Inpainting

- Toeplitz Inversion in the gated region.
- $\overline{\mathbf{C}^{-1}}\,\overline{\mathbf{x}} = -\overline{\mathbf{C}^{-1}\mathbf{n}_g}$.
- Mathematical equivalence to Time Domain truncation.




Density
Strain h
$\times 10^{-21}$
t [s]
FD
TD
Inspiral
a_f
M_f ($M_\odot$)
f
1024Hz
2048Hz
d_L
300 Mpc
600 Mpc
900 Mpc
Density

Ongoing Efforts

- Consistency checks for simulated zero-noise injections. Inclusion of Noise systematics for Inpainting.
- Analysis of LIGO GW Data for IMR Consistency tests in non-stationary noise.
- Adjunctification of *Relative Binning* in the time and frequency domains to speed up likelihood evaluations.

References

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Thank You!

Questions? Comments?