# Parameter Estimation including Resonant Effects in BNS

Gravitational Waves from Neutron Stars
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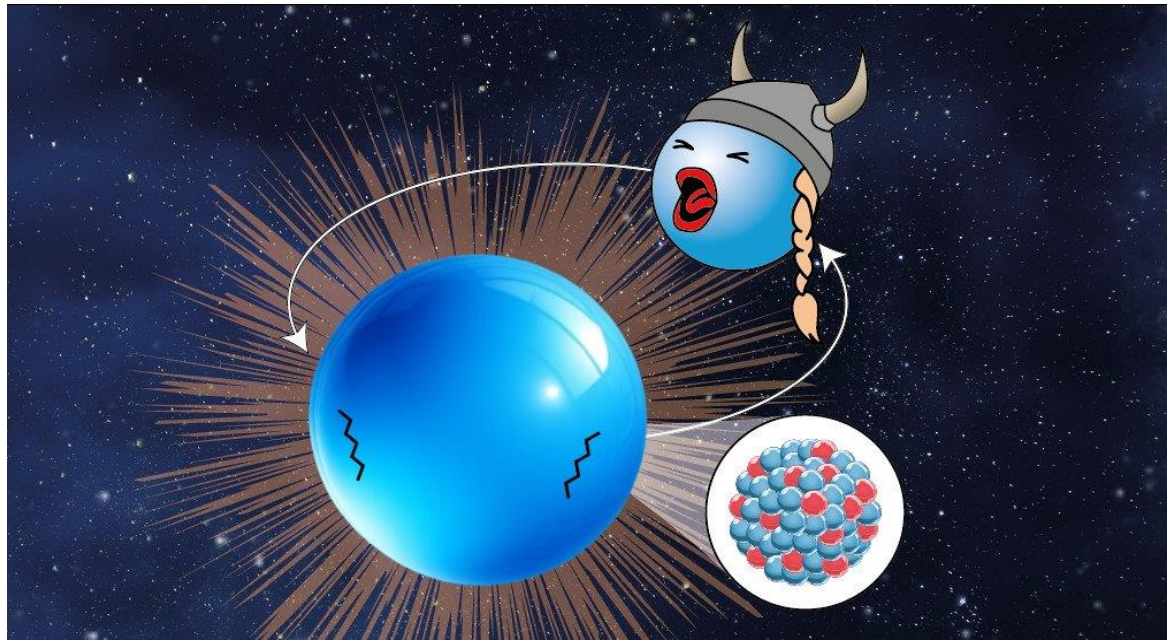
# Motivation

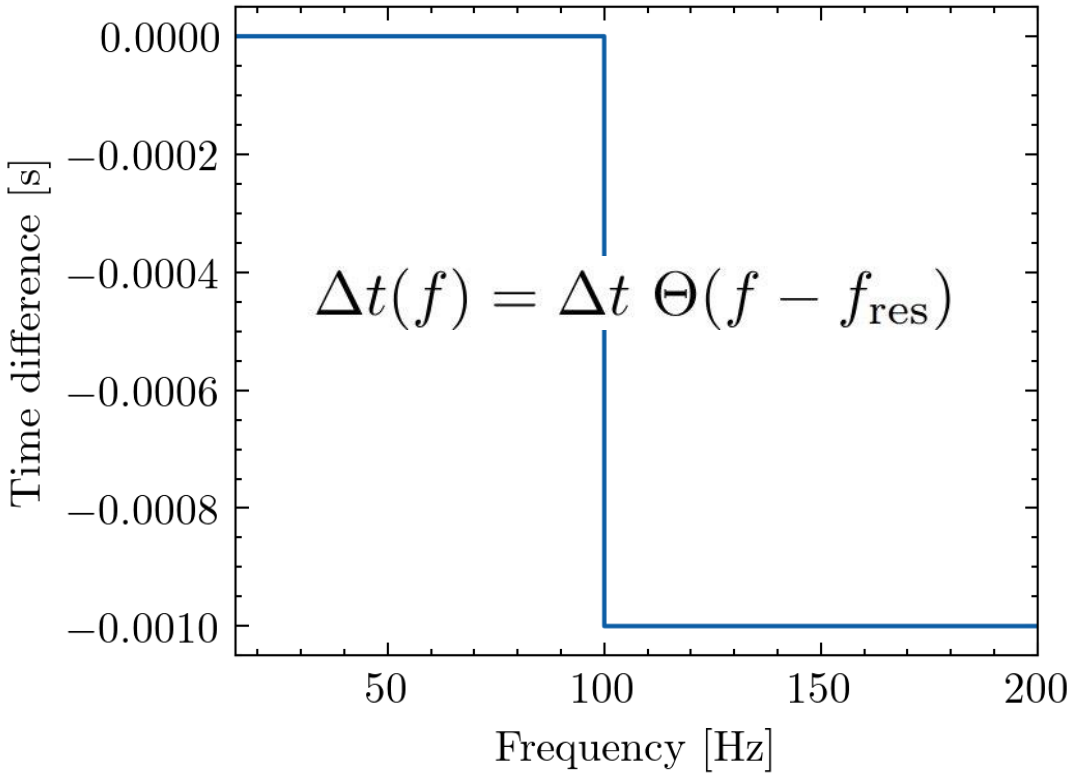
- When neutron stars merge, **oscillatory modes** are excited when the **orbital frequency** of the binary system sweeps through the **mode's resonant frequency**.
- Leading to the **transfer of energy** from the orbit to the mode.
- This energy transfer produces changes in the emitted GW **waveform**.
- In the recently published manuscript, https://doi.org/10.1103/6gm3-q143 we study the **detectability** of resonant effects in BNS signals.



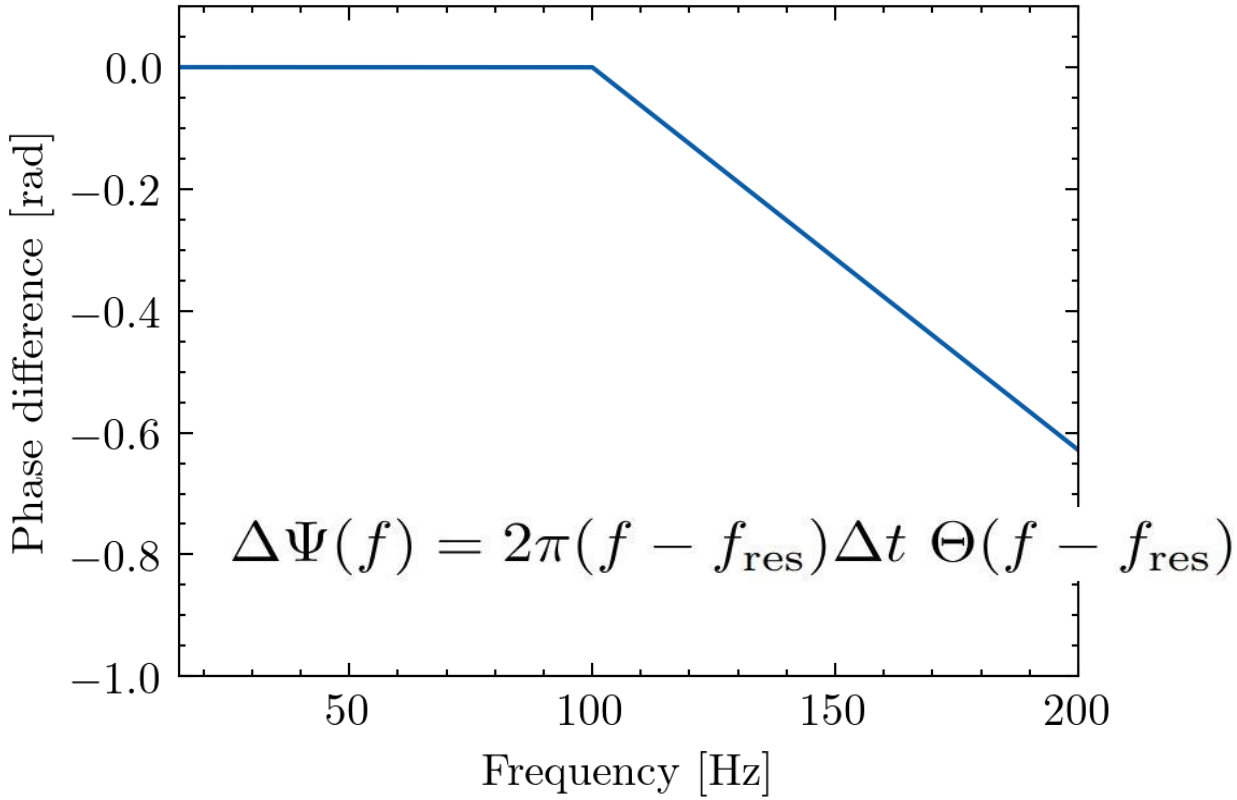
# Narrow resonance approximation effect in the waveform

$$h_\Delta(f) = h_0(f)\ e^{i\Delta\Psi(f)}$$

- The **time to merger**




- The **FD waveform phase**.

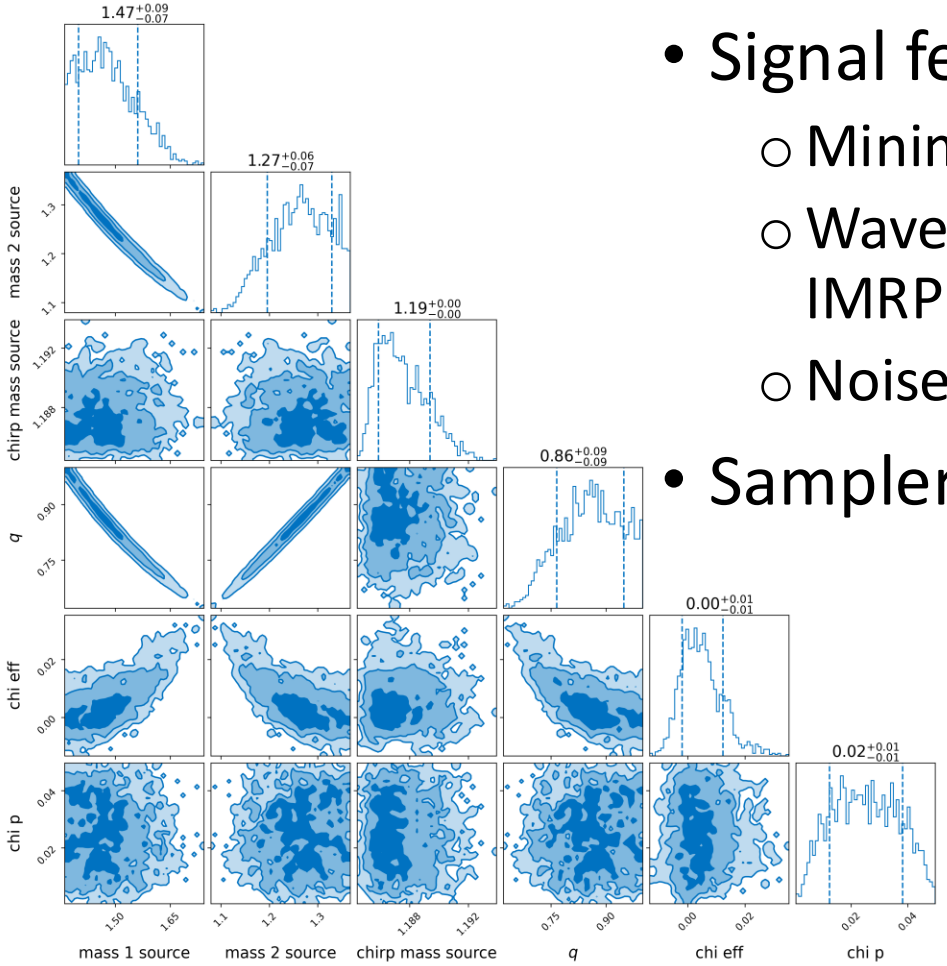


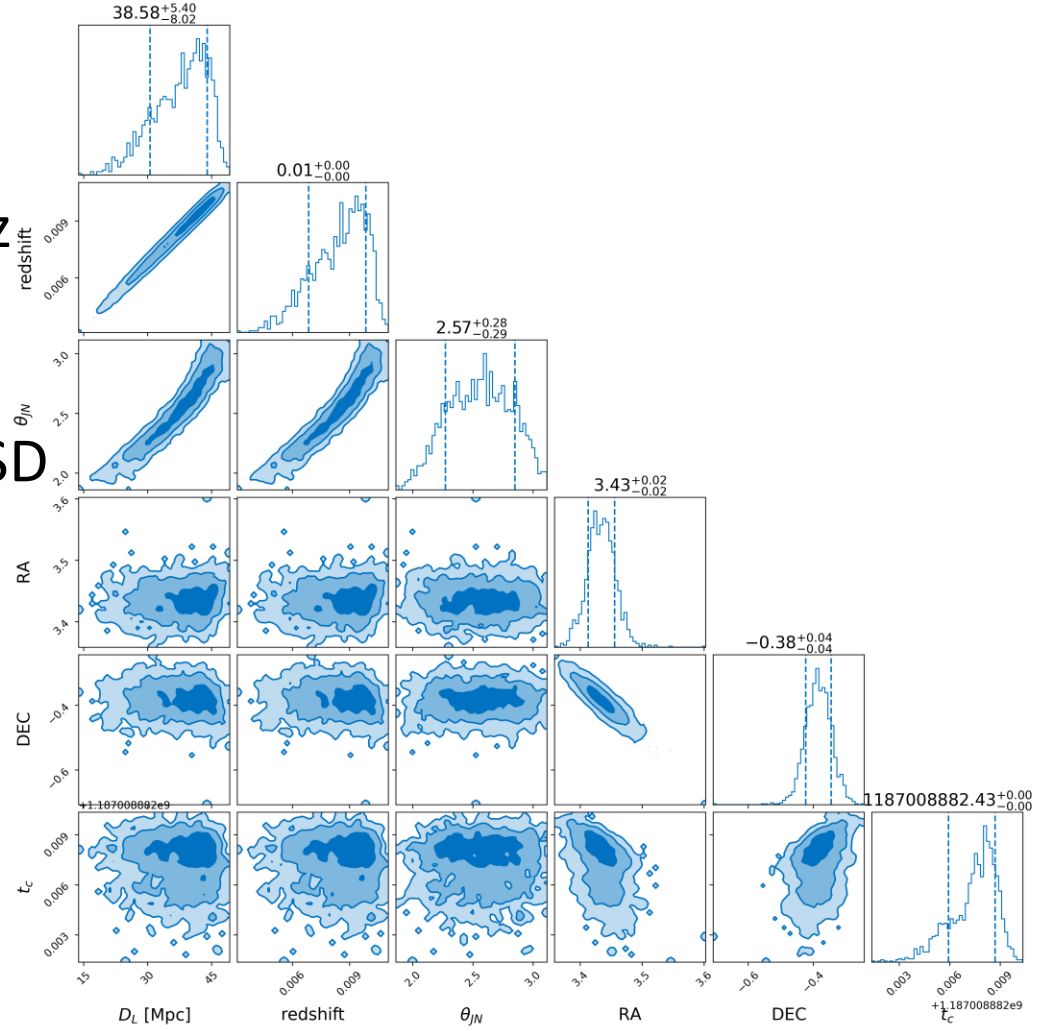
# Parameter Estimation (PE) on BNS including resonant effects

- Our goal is to develop a method to perform **PE on BNS data accounting for resonant effects**.
- PE using **bilby** and **bilby_pipe** software with off the shelf methods:
  - We run **data injections** to evaluate the detector response.
  - We perform **PE searches** for resonant effects on BNS detected signals.
- This software provides several sampling methods like:
  - Markov Chain Monte Carlo [G.Ashton & C. Talbot, 2021].
  - Nested Sampling: DYNESTY [J. S. Speagle, 2020].

# GW170817 data analysis without adding resonant effects

- Signal features:
  - Minimum frequency: 30 Hz
  - Waveform: IMRPhenomXP_NRTidalv3
  - Noise curve: GW170817 PSD
- Sampler: dynesty



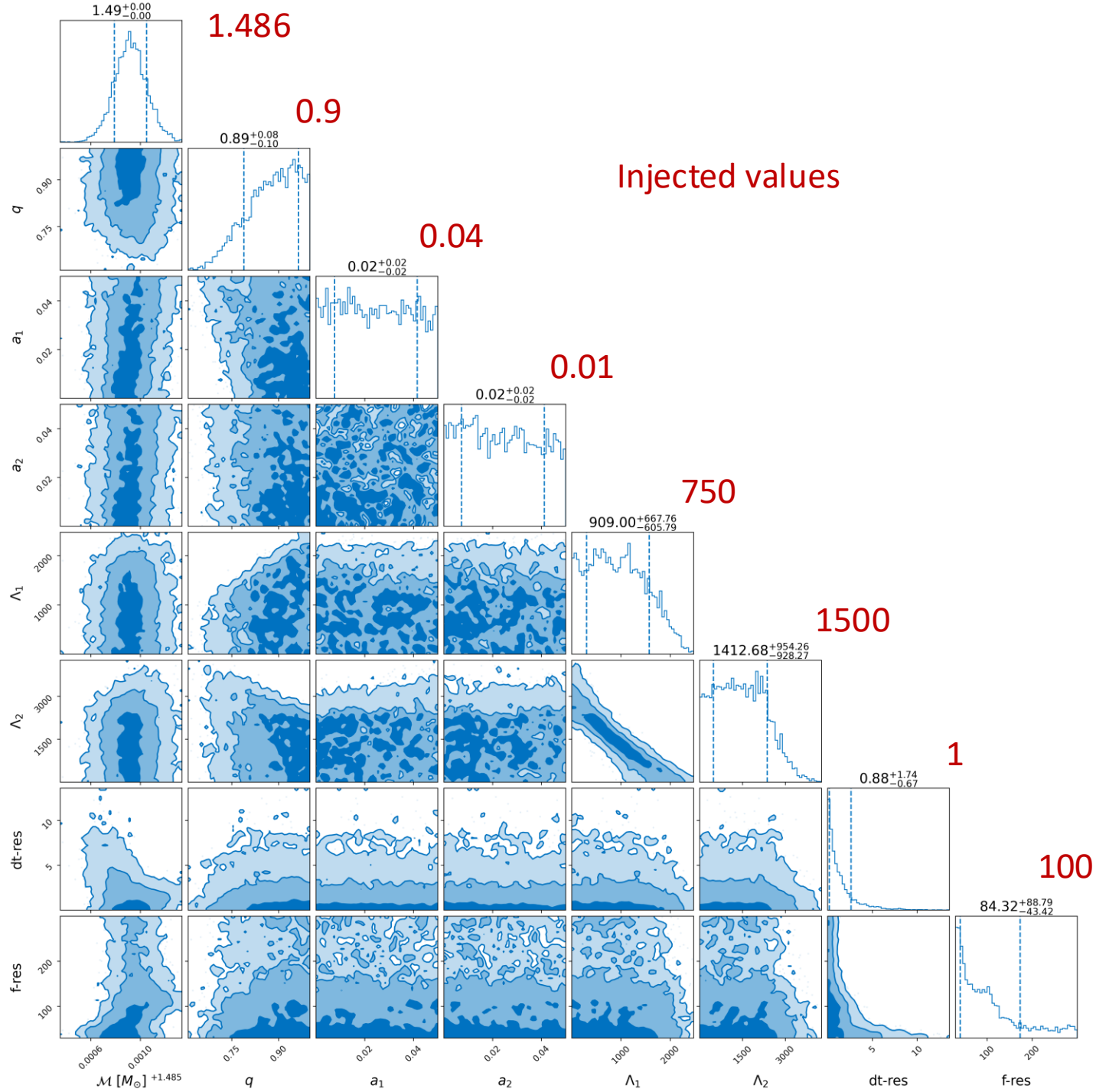
# BNS signal injections adding resonant effects

- **Waveform generation**:
  - Add the resonant contribution to the BNS waveform.
  - Fix the noise curve configuration.
- To **recover the parameters of the waveform**, we fix:
  - Priors including resonant effects:
    - **Resonant frequency** – Uniform.
    - **Time shift** – HalfExponential, LogUniform and HalfCauchy.
  - Sampling method.
  - Other techniques: marginalization, relative binning, importance sampling, ...

# Injection recovery

- Signal features:
  - Minimum frequency: 20 Hz
  - Waveform: IMRPhenomPv2_NRTidal
  - Noise curve: zero-noise injection
- Sampler: dynesty
- Resonant parameters:

$$f_{\mathrm{res}} = 100\ \mathrm{Hz}$$
$$\Delta t = 1\ \mathrm{ms}$$



# Posterior distributions