

A Test of General Relativity Using Gravitational Waves

Group Meeting, Sept 26, 2022

Aim of the Project

- To test the theory of GR using data from binary mergers
- To predict the results of the next GW detectors
- To study modified dispersion relations in context of 3G detectors

Current Objective

- To analyse SNR for:
 - Different total masses
 - Different distances
 - Different values of β

$$\beta \equiv \frac{\pi^2 D \mathcal{M}}{\lambda_g^2 (1 + Z)} .$$

Progress

Evaluation of Strain

$$A(\tilde{f}) \equiv \mathcal{A}\tilde{f}^{-7/6} = \sqrt{\frac{\pi}{30}} \frac{\mathcal{M}^2}{D_L} u^{-7/6}$$

$$\begin{aligned}\Psi(\tilde{f}) = & 2\pi\tilde{f}t_c - \Phi_c - \pi/4 + \frac{3}{128}u^{-5/3} - \beta u^{-1} \\ & + \frac{5}{96} \left(\frac{743}{336} + \frac{11}{4}\eta \right) \eta^{-2/5} u^{-1} \\ & - \frac{3\pi}{8} \eta^{-3/5} u^{-2/3}\end{aligned}$$

Evaluation of Strain

$$\tilde{h}(\tilde{f}) = \begin{cases} \tilde{A}(\tilde{f})e^{i\Psi(\tilde{f})}, & 0 < \tilde{f} < \tilde{f}_{\max} \\ 0, & \tilde{f} > \tilde{f}_{\max} \end{cases}$$

Evaluation of Strain

```
In [872]: def amplitude(f):  
    A = math.sqrt(math.pi / 30) * (M ** 2 / D_L) * u(f) ** (-7/6)  
    return A
```

```
In [873]: def psi(f):  
    phase = (2 * math.pi * f * t_c) - phi_c - math.pi/4. + (3./128. * u(f)**(-5./3.))  
    - (beta * u(f)**(-1.))  
    + (5./96. * (743./336.) + (11./4. * eta) * eta**(-2./5.) * u(f)**(-1.))  
    - (3. * math.pi/8. * eta**(-3./5.) * u(f)**(-2./3.))  
    return phase
```

```
In [874]: def h(f):  
    H = amplitude(f) * scipy.constants.e**(1j * psi(f))  
    return H
```

Calculation of SNR

$$(h_1|h_2) \equiv 2 \int_0^\infty \frac{\tilde{h}_1^* \tilde{h}_2 + \tilde{h}_2^* \tilde{h}_1}{S_n(f)} df$$

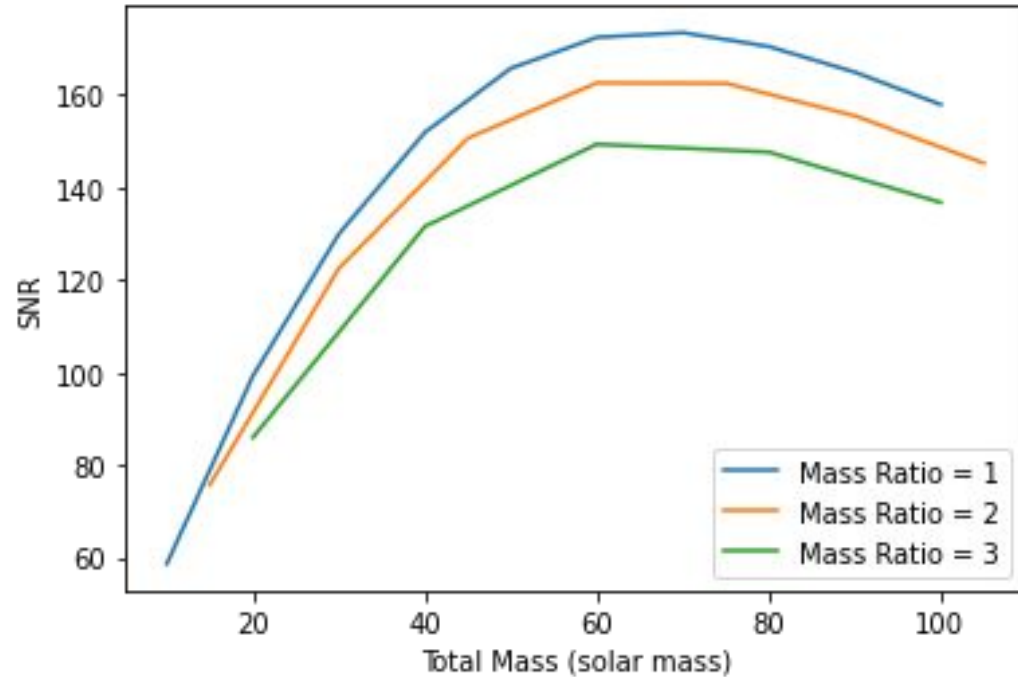
$$\rho[h] \equiv S/N[h] = (h|h)^{1/2}$$

What we've achieved so far—

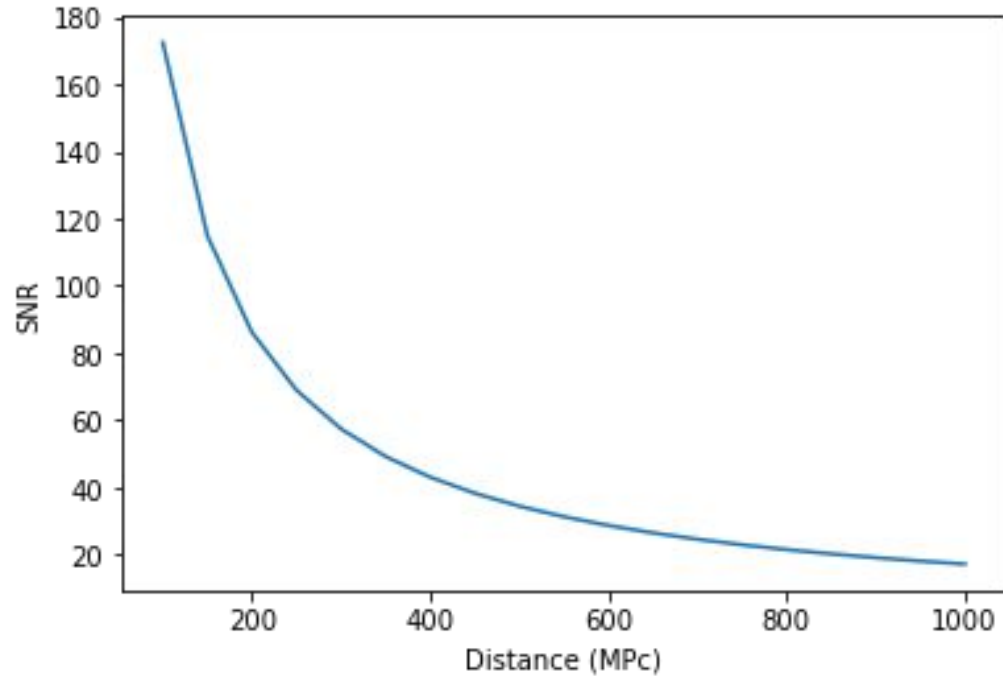
- Analysis of SNR for different systems
 - Different masses
 - Different distances
- Analysis of effect of different mass ratios on SNR

Results

SNR for Different Masses



SNR for Different Distances



SNR for Different β

- Unable to reflect change in β for different graviton masses

Future Plans

- Analyse the variation in SNR for different β
- Analyse SNR for different detectors
- Optimise code for faster computation