

# Tracing large scale structures with gravitational waves

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Mapelli, Matarrese

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## Luminosity Distance Space Distortions

$$\chi(D_L^{obs}) = \chi(\bar{D}_L) + \left[ \frac{2\bar{D}_L}{1+z} \left( \frac{\partial \bar{D}_L}{\partial z} \right)^{-1} \right] \frac{\vec{v} \cdot \hat{n}}{f_{DL}}$$

## Lensing

$$\delta_{LDS}^{obs} = \delta - 2\kappa + \left( \alpha + \frac{f_{DL}}{2\mathcal{H}} \frac{d}{d\chi} \right) \kappa$$
$$\alpha = \frac{1}{1+\chi\mathcal{H}} \left( 3 + \frac{d \ln n(\chi)}{d \ln \chi} - \frac{f_{DL}}{2} + \frac{f_{DL}\chi\mathcal{H}_{,\eta}}{2\mathcal{H}} \right)$$

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# Model source distribution and bias

Simulated binary black holes and binary neutron stars in galaxies

→ Observations through Einstein Telescope (~2030)

Artale et al.,  
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MNRAS 491 (2020) 3419

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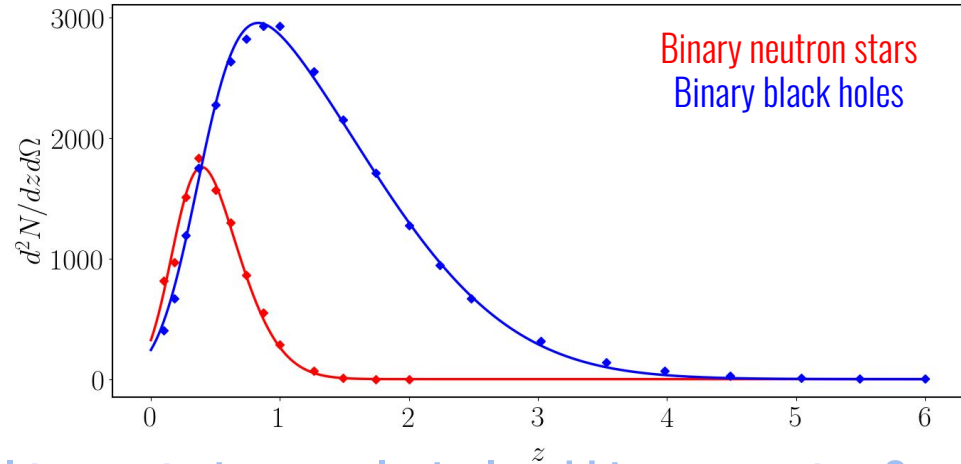
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## Observed number density

$$N_m(z) = T^{\text{OBS}} \frac{N_m^{\text{SIM}}(z)}{T^{\text{SIM}}(z)} \frac{1}{1+z}$$

$$\frac{d^2 N_m}{dz d\Omega} = N_m(z) \frac{c}{\ell H(z)} \left( \frac{D_L(z)}{\ell (1+z)^2} \right)^{-2}$$



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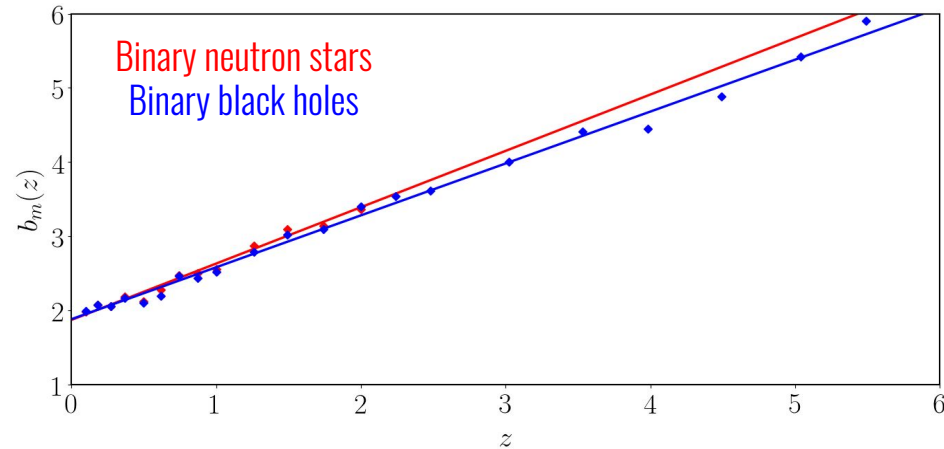
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**Bias (analytical, HOD based)**

$$b_m(z) = \int_{M_*^{\min}}^{M_*^{\max}} dM_* \int_{SFR^{\min}}^{SFR^{\max}} dSFR$$

$$n_g(z, M_*, SFR) b_g(z, M_*, SFR) \frac{\langle N_m(z) | M_*, SFR \rangle}{n_m(z)}$$



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3 Einstein Telescope x 3 years survey

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Tomographic angular power spectra

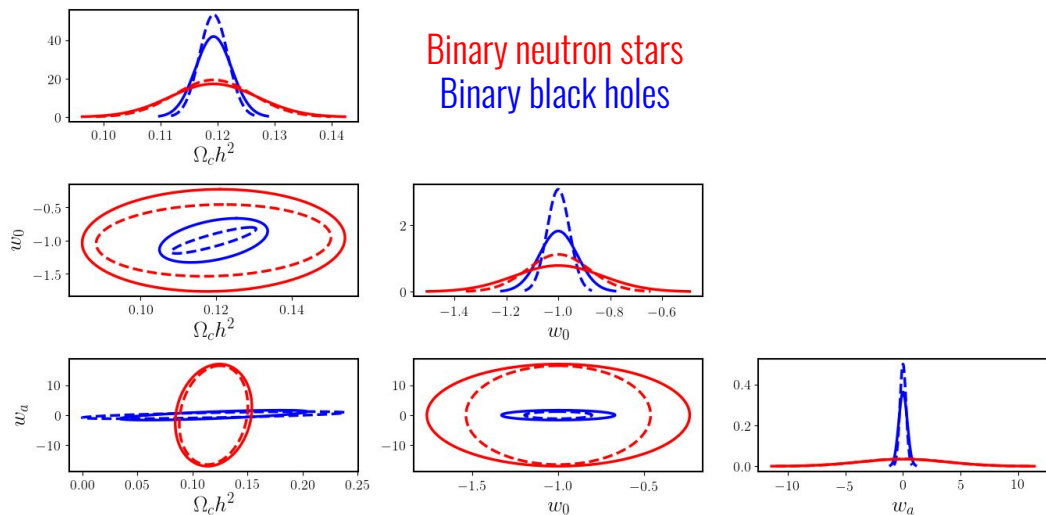
Fisher matrix analysis

$$\Theta = [H_0, \Omega_c h^2, w_0, w_a, b_m^0, \dots, b_m^n]$$

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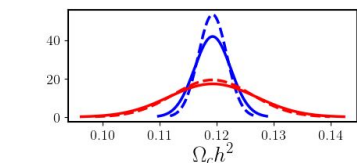
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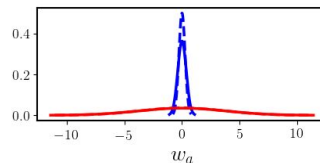
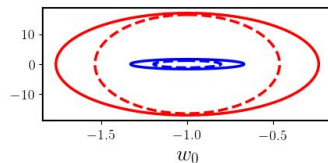
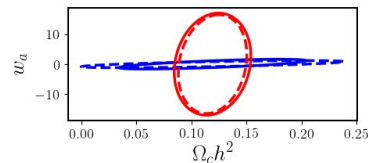
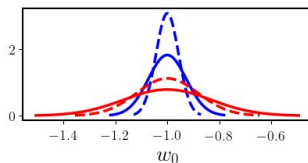
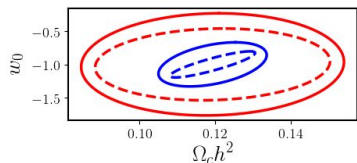
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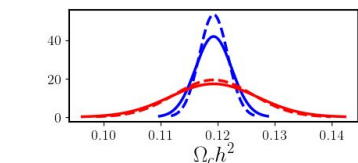
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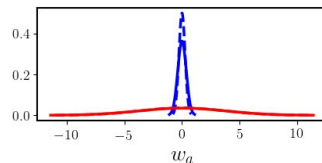
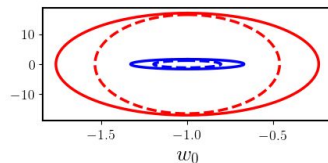
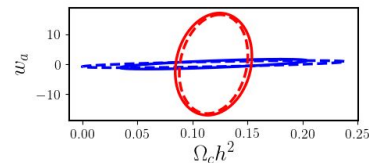
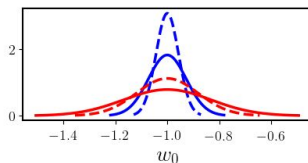
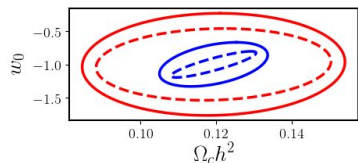
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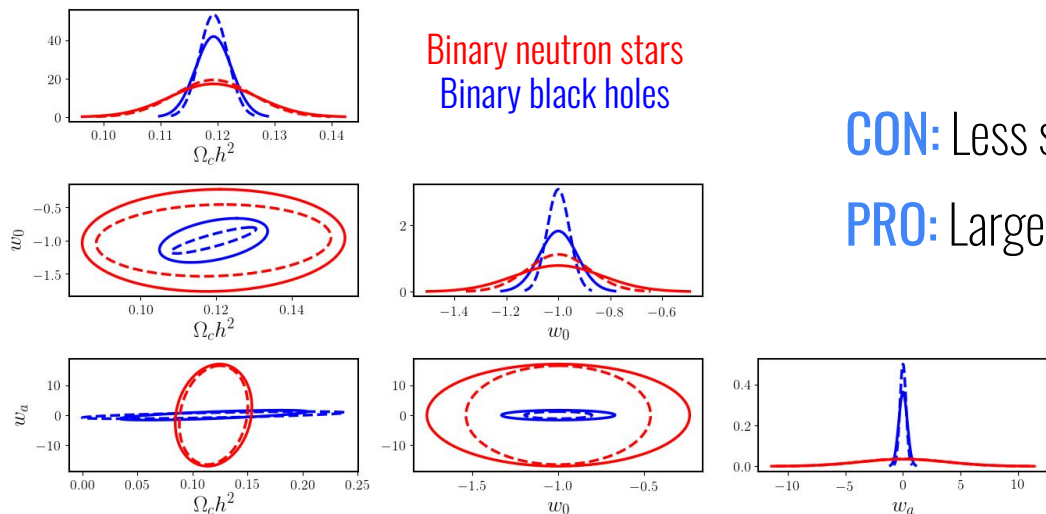
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Understand constraining power on  
**primordial non gaussianity**

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# Bias parameters Forecasts

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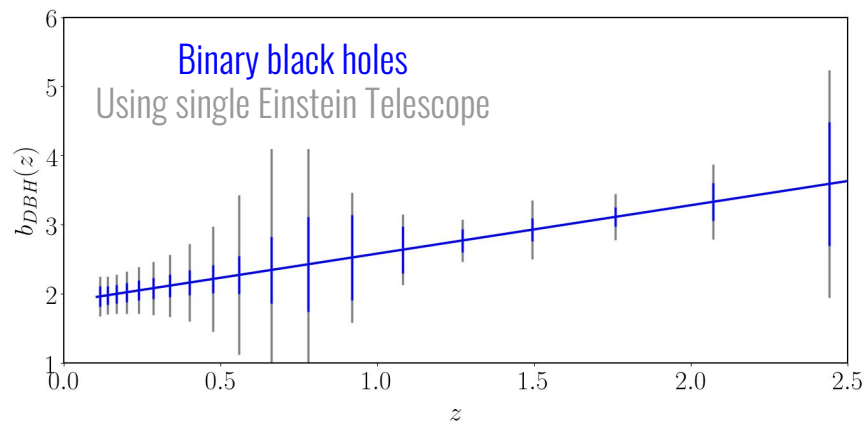
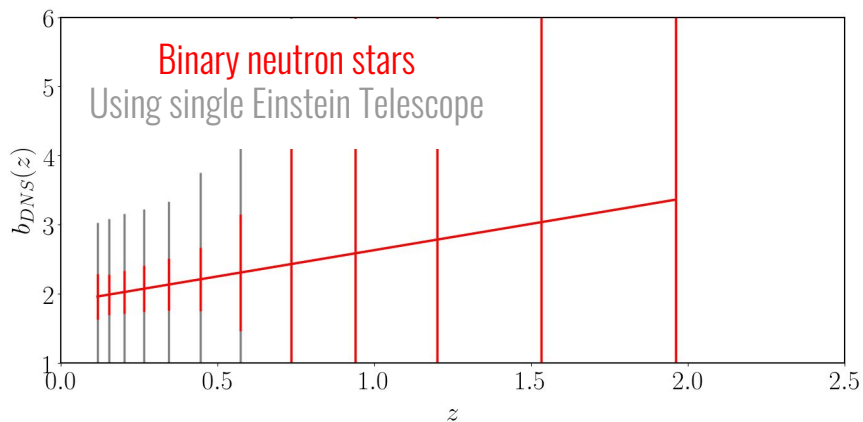
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**PRO:** Merger bias should be detectable  
by Einstein Telescope alone at high significance

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**Thank you for your attention!**