

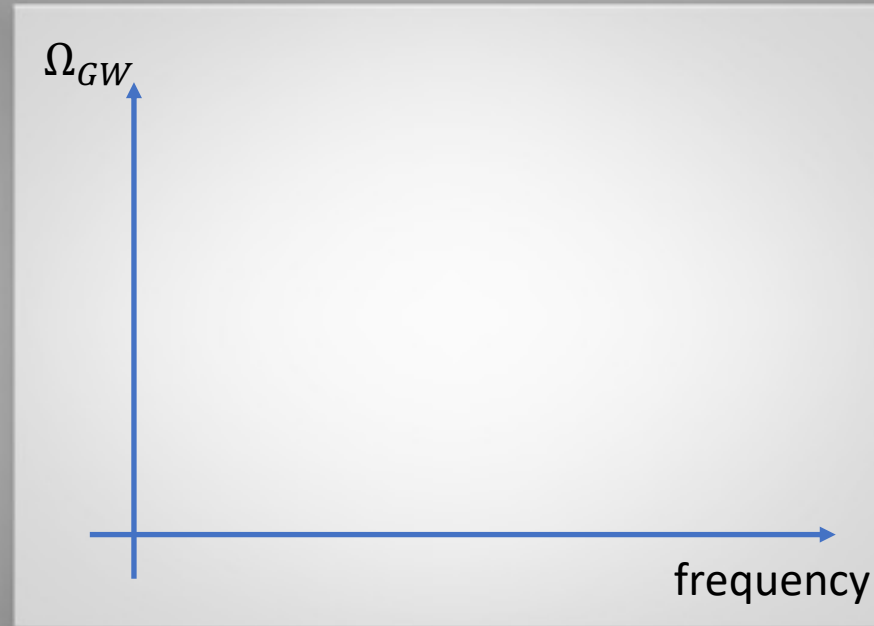
Gravitational Wave Primordial Cosmology

Panel discussion:

Induced Gravitational Waves from Density Perturbations

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Primordial Gravitational Waves



Induced stochastic gravitational wave background from density perturbations after inflation

- Guaranteed signal ✓

Tomita '67, Matarrese et al '93, Ananda et al '06 , Baumann et al '07 [*Domenech*]

- but amplitude model-dependent: $\Omega_{GW} \approx 10^{-6} (P_\zeta)^2$

- canonical slow-roll: $P_\zeta \sim 10^{-9}$ on CMB scales implies $\Omega_{GW} \sim 10^{-24}$

- observable only for large enhancement of primordial density perturbations

- *model-dependent, or fine-tuned?* [*Clesse*]

Induced stochastic gravitational wave background from density perturbations after inflation

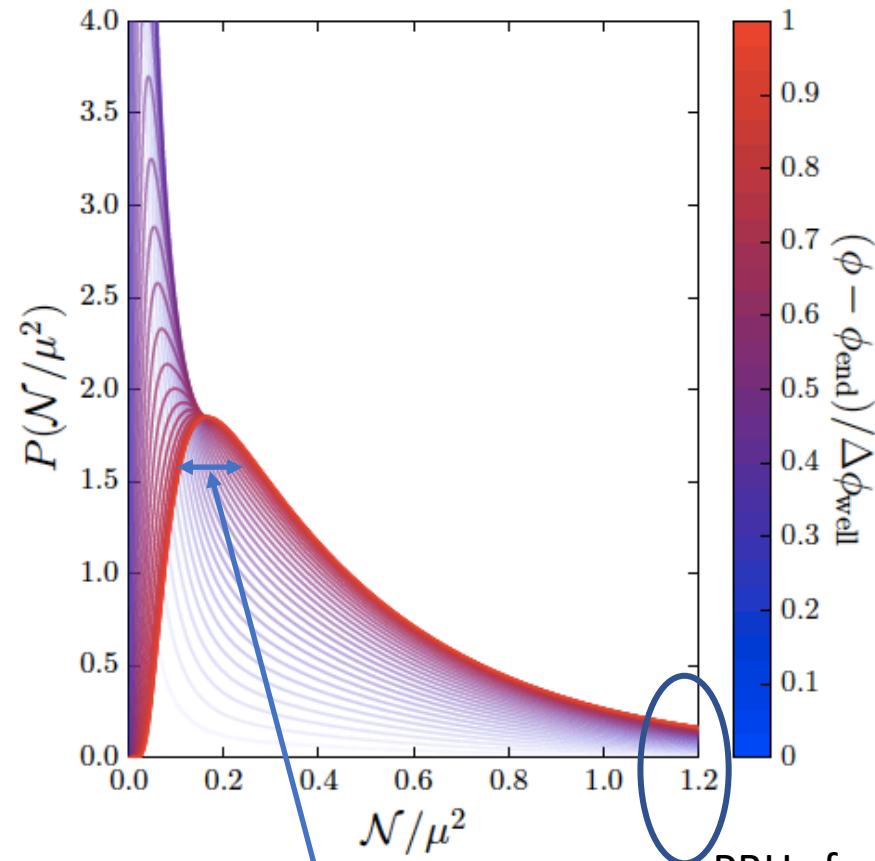
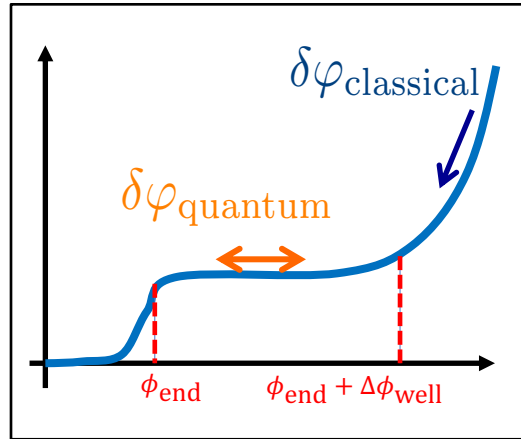
- How would we distinguish primordial signals?
 - power spectrum shape, $\Omega_{GW}(f)$
 - sharp peak vs broad bump [*Braglia*]
 - oscillations [*Witkowski*]
 - high-frequency cut-off [*Unal*]
 - *trade-off between frequency resolution and sensitivity* [*Pieroni*]
 - non-Gaussianity, B_{GW} , or anisotropy, $C_{l,\Omega_{GW}}$
 - *not for second-order SGWB?*

Induced stochastic gravitational wave background from density perturbations after inflation

- How would we distinguish primordial signals?
 - characteristic scale, f_{peak}
 - related to physical energy scales
 - slow-roll inflation (almost) scale-agnostic
 - radiation-era horizon size (e.g., end of inflation): $f_*/10^{-9}\text{Hz} \approx T/100\text{MeV}$
 - *production of primordial black holes: $M/M_{solar} \approx (f_*/10^{-9}\text{Hz})^2$ [Pi, Riotto, Clesse...]*
 - *PBH abundance due to (non-Gaussian) tail of density perturbations*

Exponential tail of $P(\zeta)$ due to quantum diffusion

Pattison, Vennin, Assadullahi & DW (2017); Ezquiaga, Garcia-Bellido & Vennin (2019); Figueroa et al (2020);...



PBHs form from rare, large fluctuations

typical density waves which generate gravitational waves

Induced stochastic gravitational wave background from density perturbations after inflation

- Effective theory approach
 - *constrain effective-theory parameters from SGWB power spectrum*
 - *Link to PBH production at same scale*
 - *But only for (quasi-)Gaussian primordial density field*
- Model-building approach
 - Connect SGWB to other observables
 - PBH abundance, including non-Gaussian primordial density field
 - CMB constraints on amplitude and scale dependence on CMB scales
 - Spectral distortions on intermediate scales
 - SGWB across a range of scales