Primordial black holes dark matter from inflection point models of inflation and the effects of reheating

arXiv: 1907.04125

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Outline of the talk

- Why Primordial Black Holes (PBH) ?
- PBH genesis from inflection point inflationary models
- Some caveats with calculating PBH mass fraction
- Results
  - Primordial scalar spectra and PBH abundance for dark matter
  - Effects of reheating on PBHs
- Conclusions and Summary

Why Primordial Black Holes (PBH) ?

- Interesting objects generated in the early universe e.g. during the inflationary phase

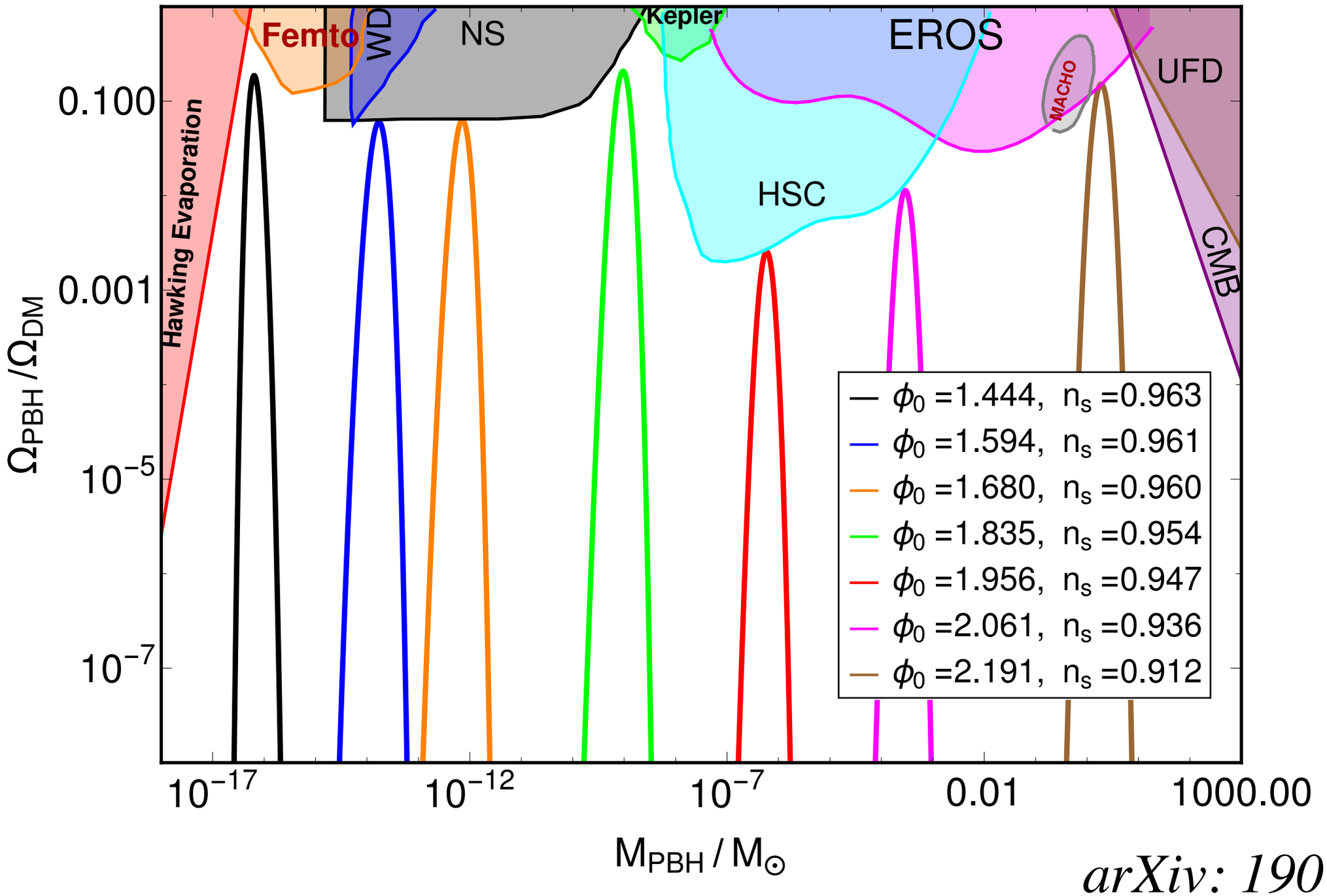
- Non-baryonic, non-relativistic and nearly collisionless

- A novel and promising candidate for cold dark matter

- No new physics (e.g. BSM) required

- Also relevant for the recent detection of GWs from (super) massive black holes — origin in PBHs

Observational constraints



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Scalar field potential with an inflection point

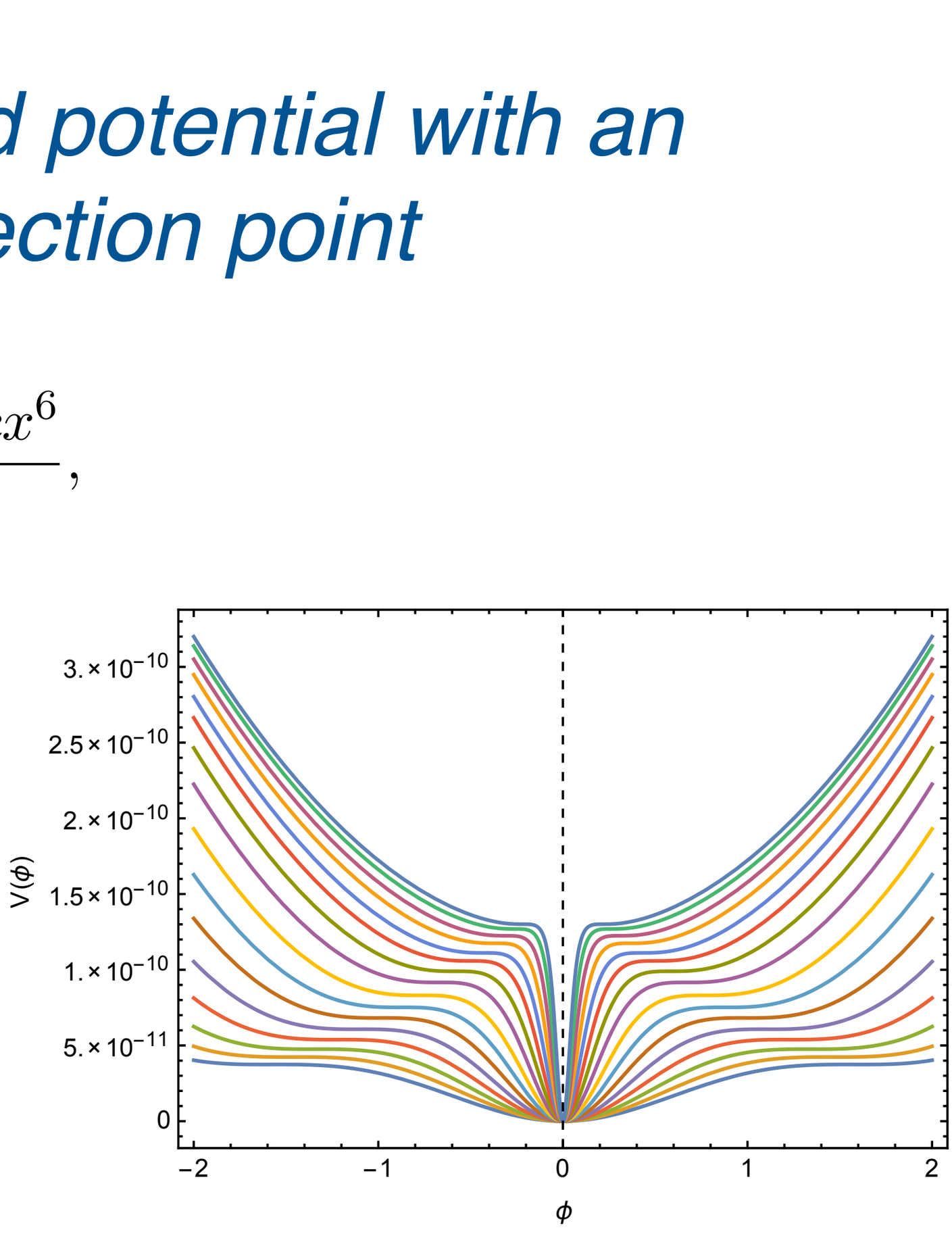
$$V(x) = V_0 \, \frac{ax^2 + bx^4 + cx^6}{(1 + dx^2)^2},$$

$$x \gg 1 : V(x) \simeq \frac{V_0 c}{d^2} x^2$$

$$x \ll 1 : V(x) \simeq V_0 a x^2$$

Quadratic for both large & small field values

$$r \sim 0.05$$



Slow roll, ultra slow roll and all that…

Background

$$H^2 = \frac{V(\phi)}{M_{\rm Pl}^2(3-\epsilon)},$$

$$\frac{d^2\phi}{dN^2} + (3-\epsilon)\frac{d\phi}{dN} + \frac{1}{H^2}V'(\phi) = 0,$$

SR: $\frac{d\phi}{dN} + \frac{1}{3H^2}V'(\phi) \simeq 0,$

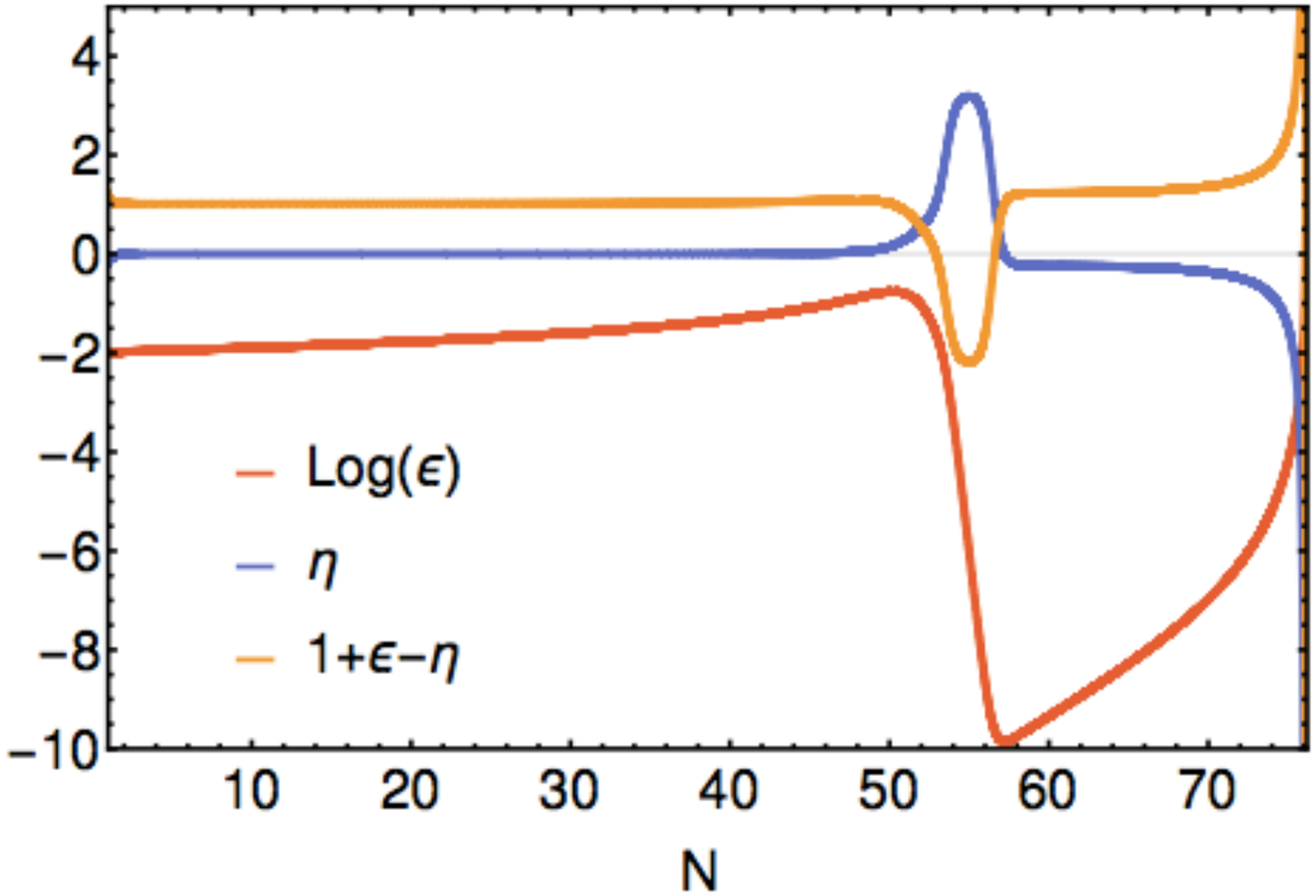
USR: $\frac{d^2\phi}{dN^2} + 3\frac{d\phi}{dN} \simeq 0,$

Curvature perturbations

$$\mathcal{R}_k'' + 2\left(\frac{z'}{z}\right)\mathcal{R}_k' + k^2\mathcal{R}_k = 0.$$

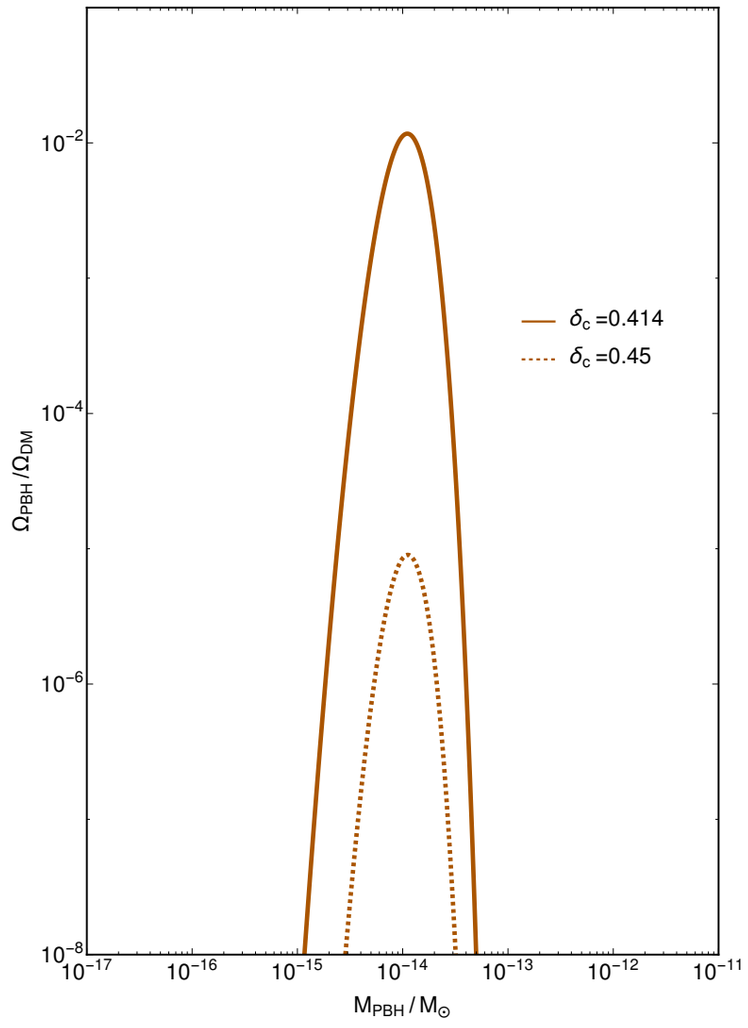
$$\frac{z'}{z} = aH(1+\epsilon-\eta)$$

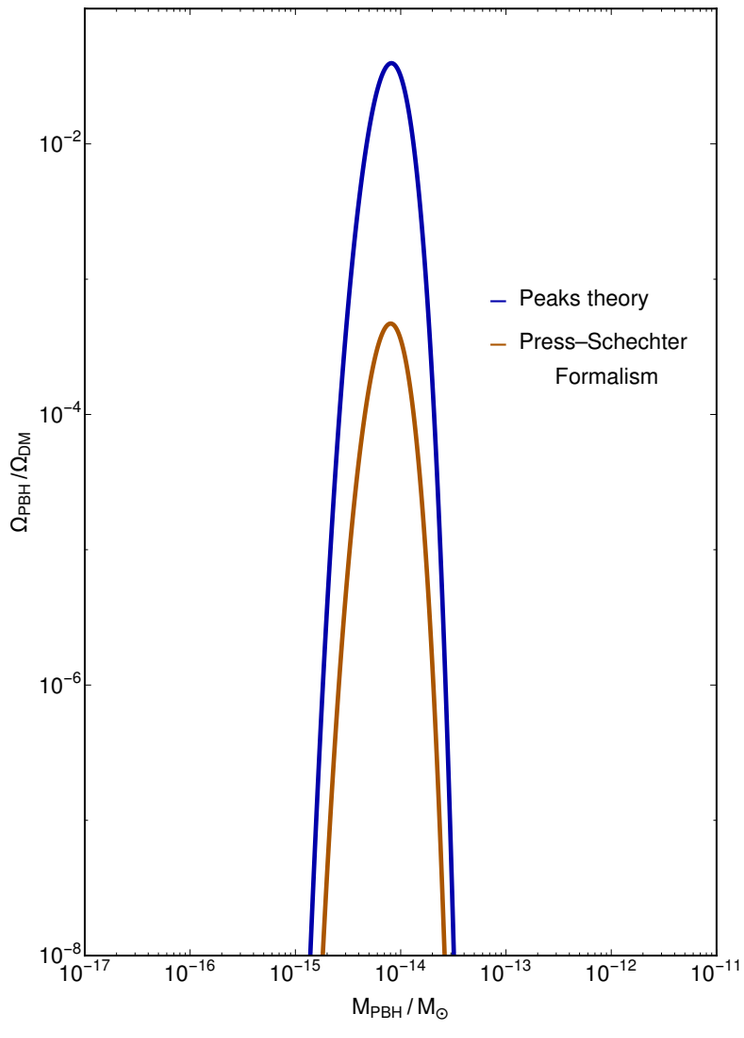
$$\mathcal{R}_k(\tau) \simeq C_1 + C_2\int\frac{d\tau}{z^2}$$



PBH mass fraction calculation (some caveats …)

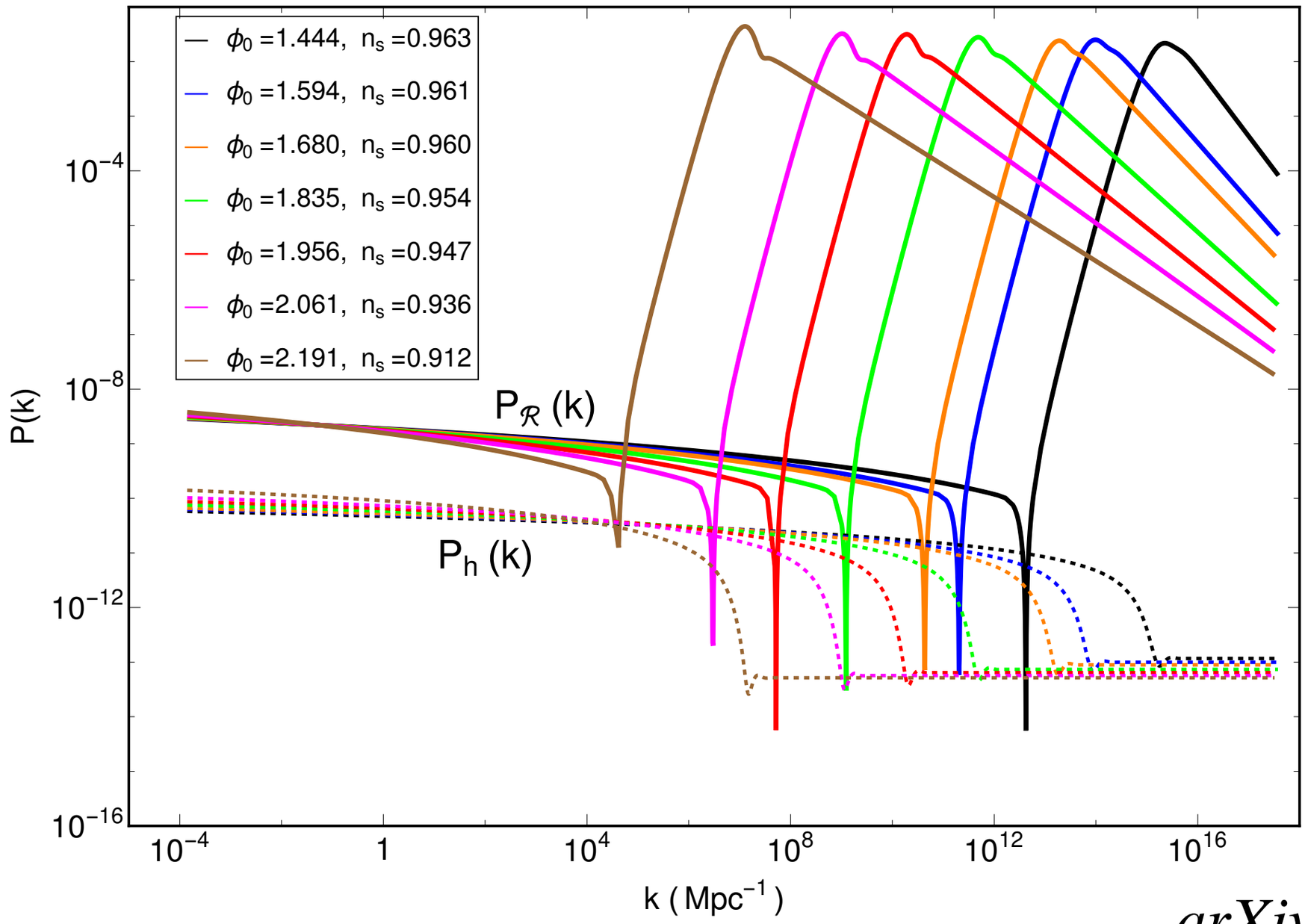
- Peaks theory vs. Press-Schechter
- Choice of the window function
- Value of the critical density contrast





Results

Primordial scalar spectra



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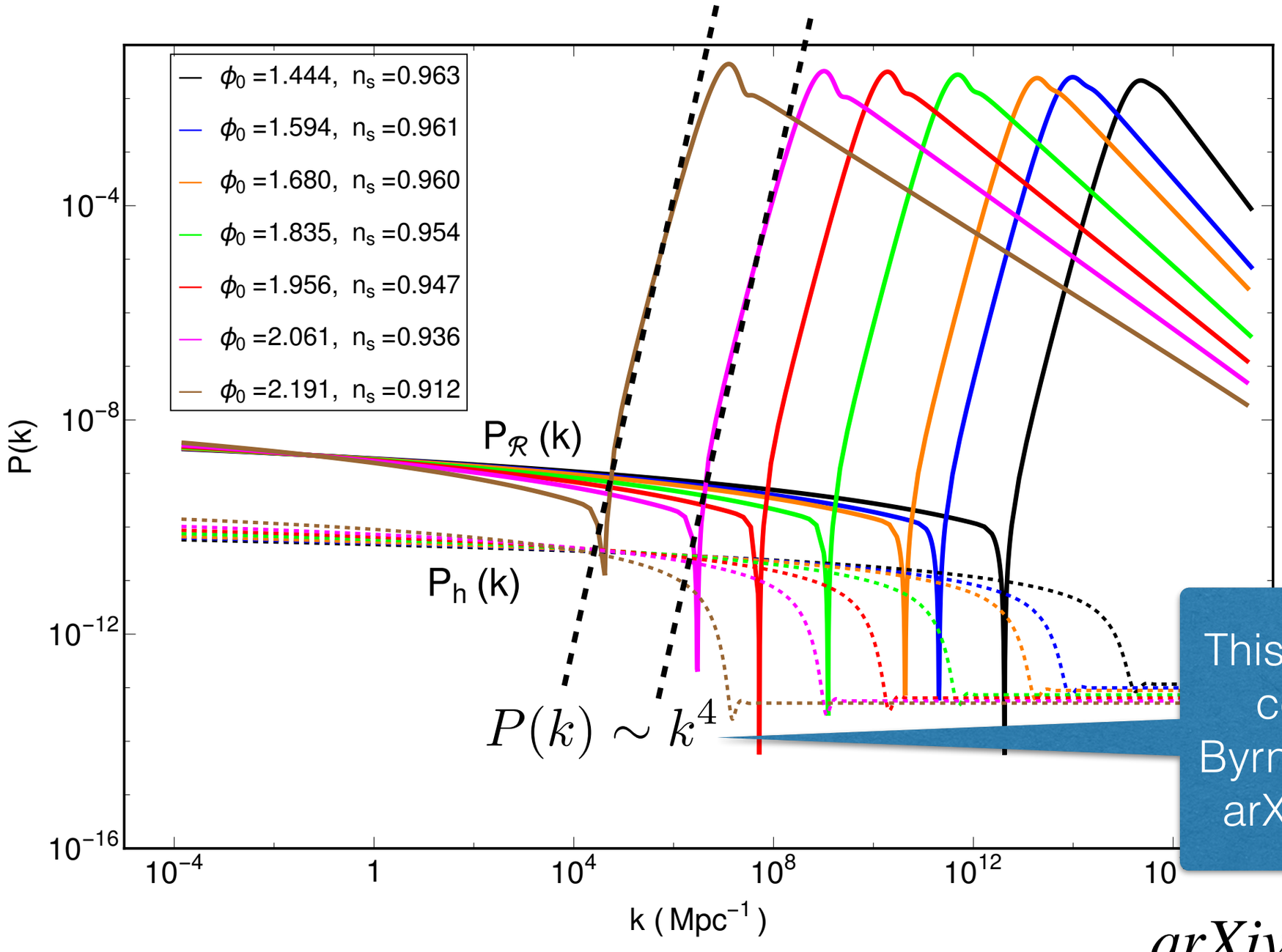
Primordial scalar spectra



This steep growth is consistent with Byrnes, Cole & Patil; arXiv: 1811.11158

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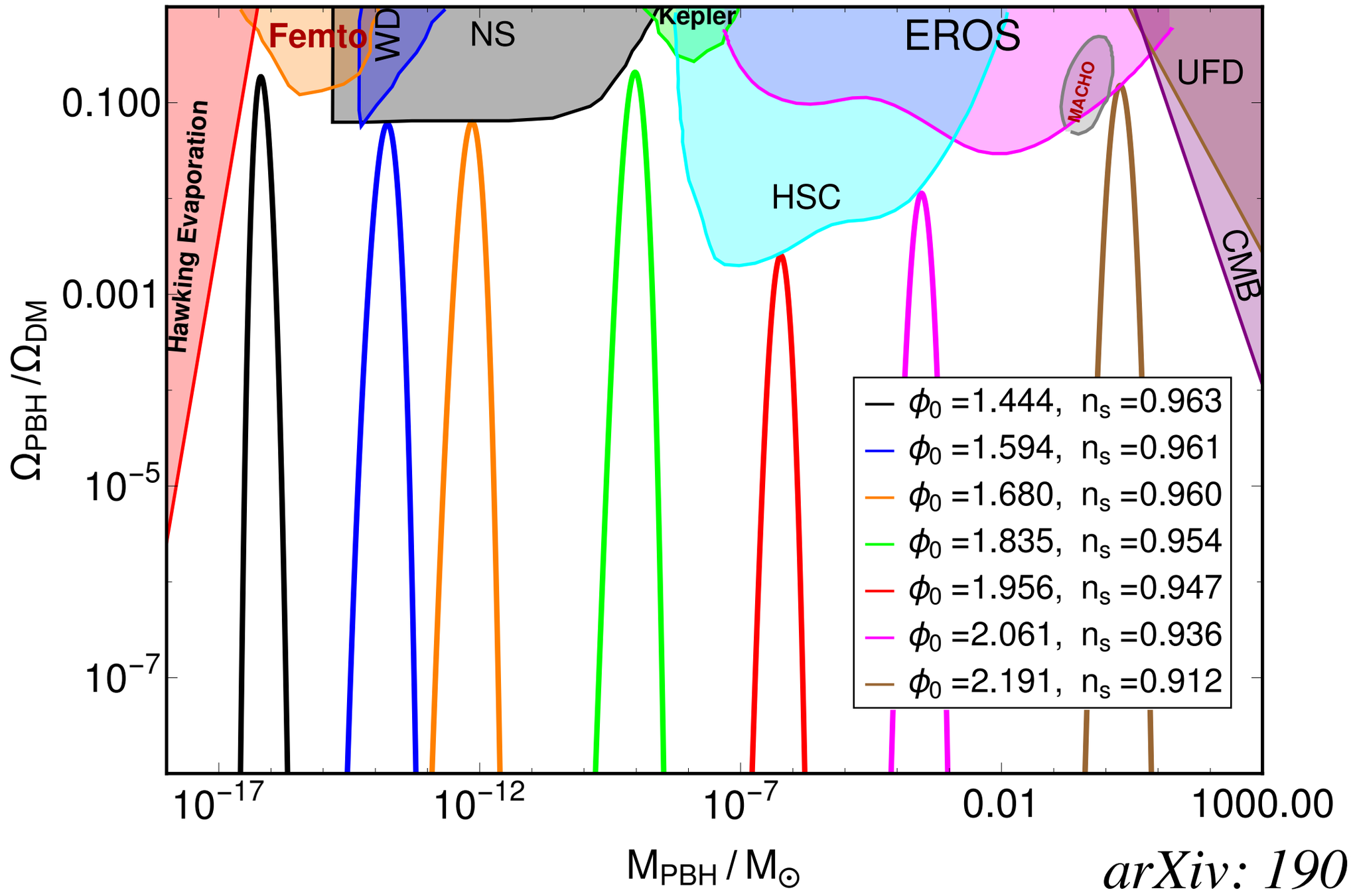
Results

PBH mass fraction



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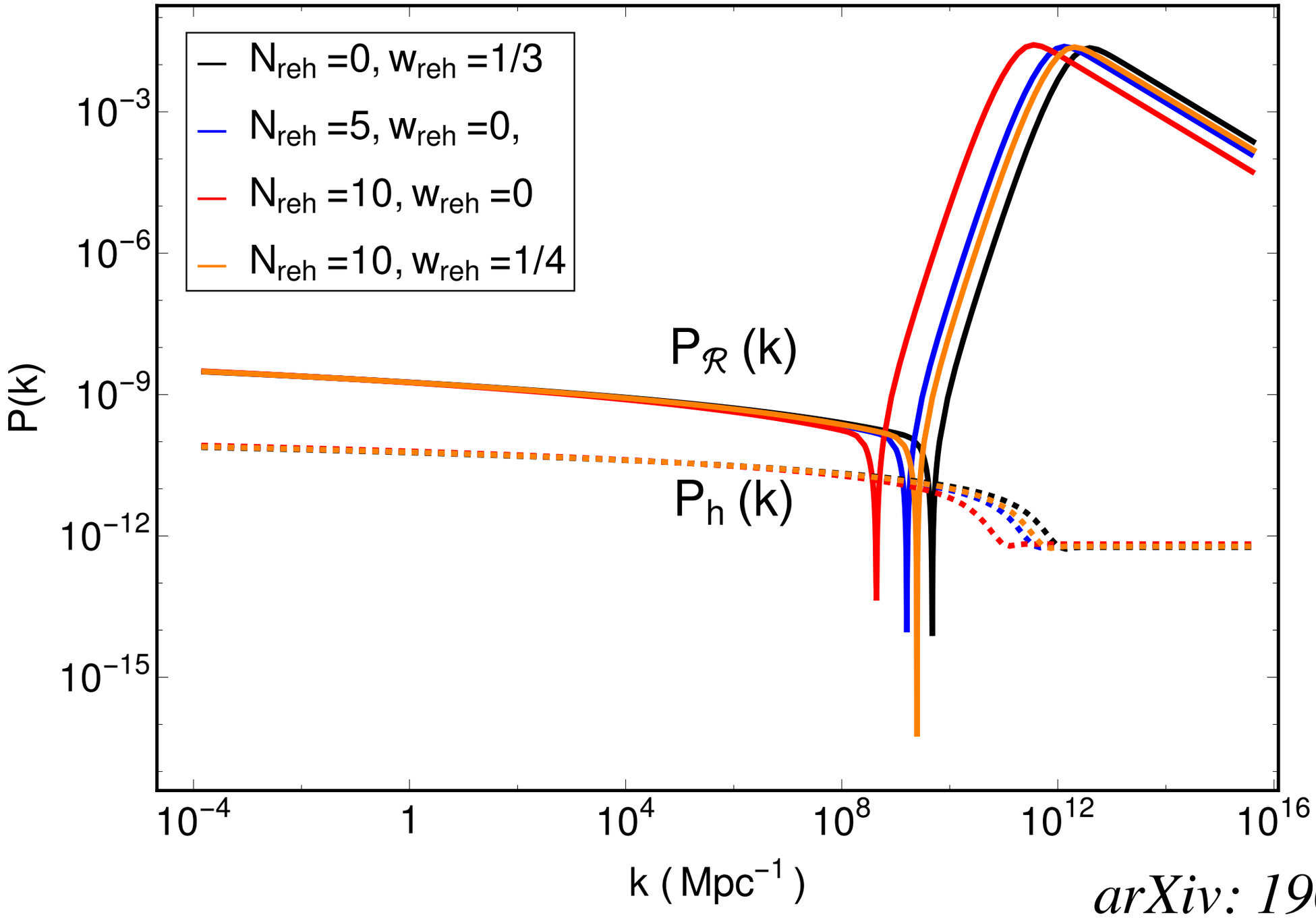
Results

Effects of reheating on the power spectra



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Results

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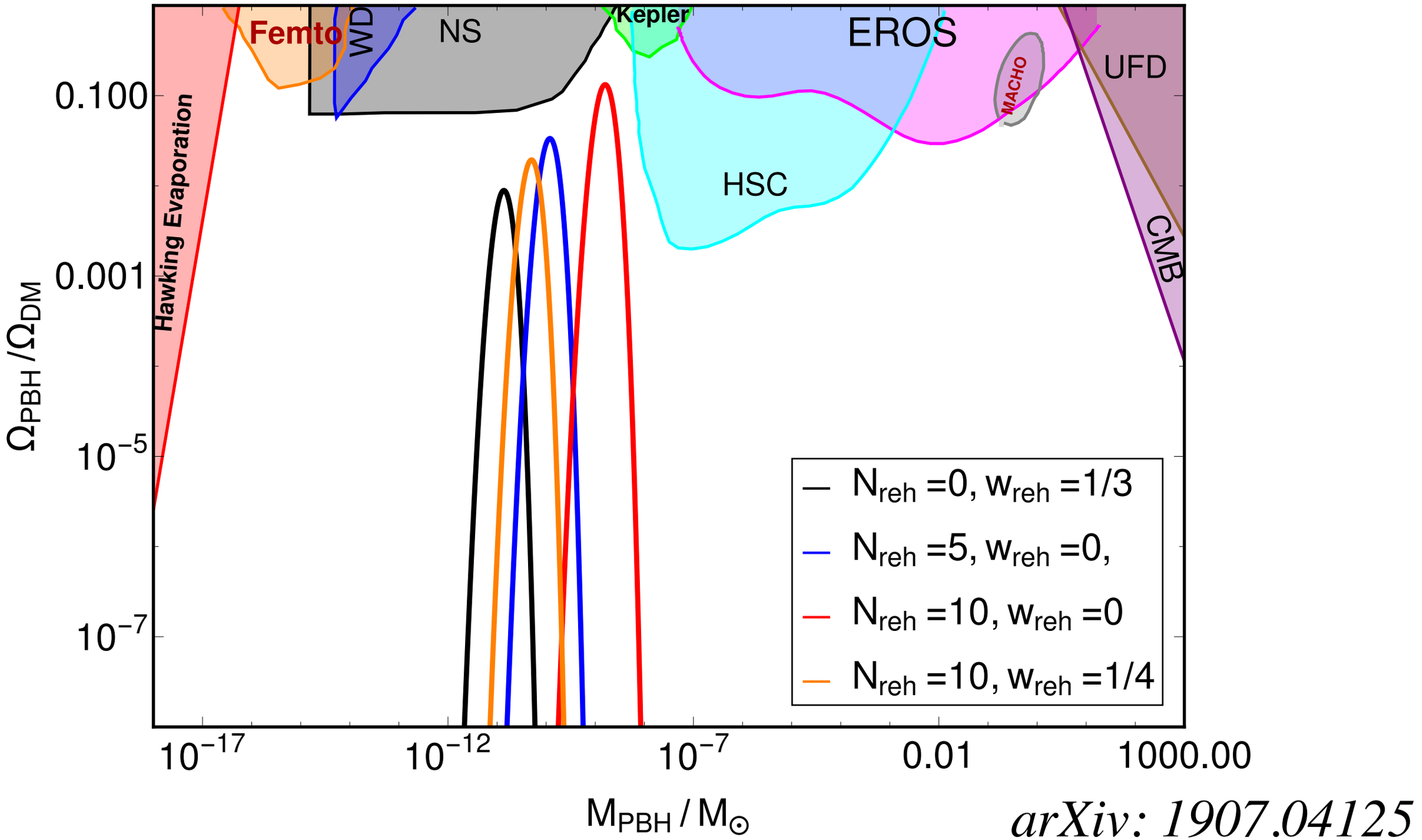

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Results

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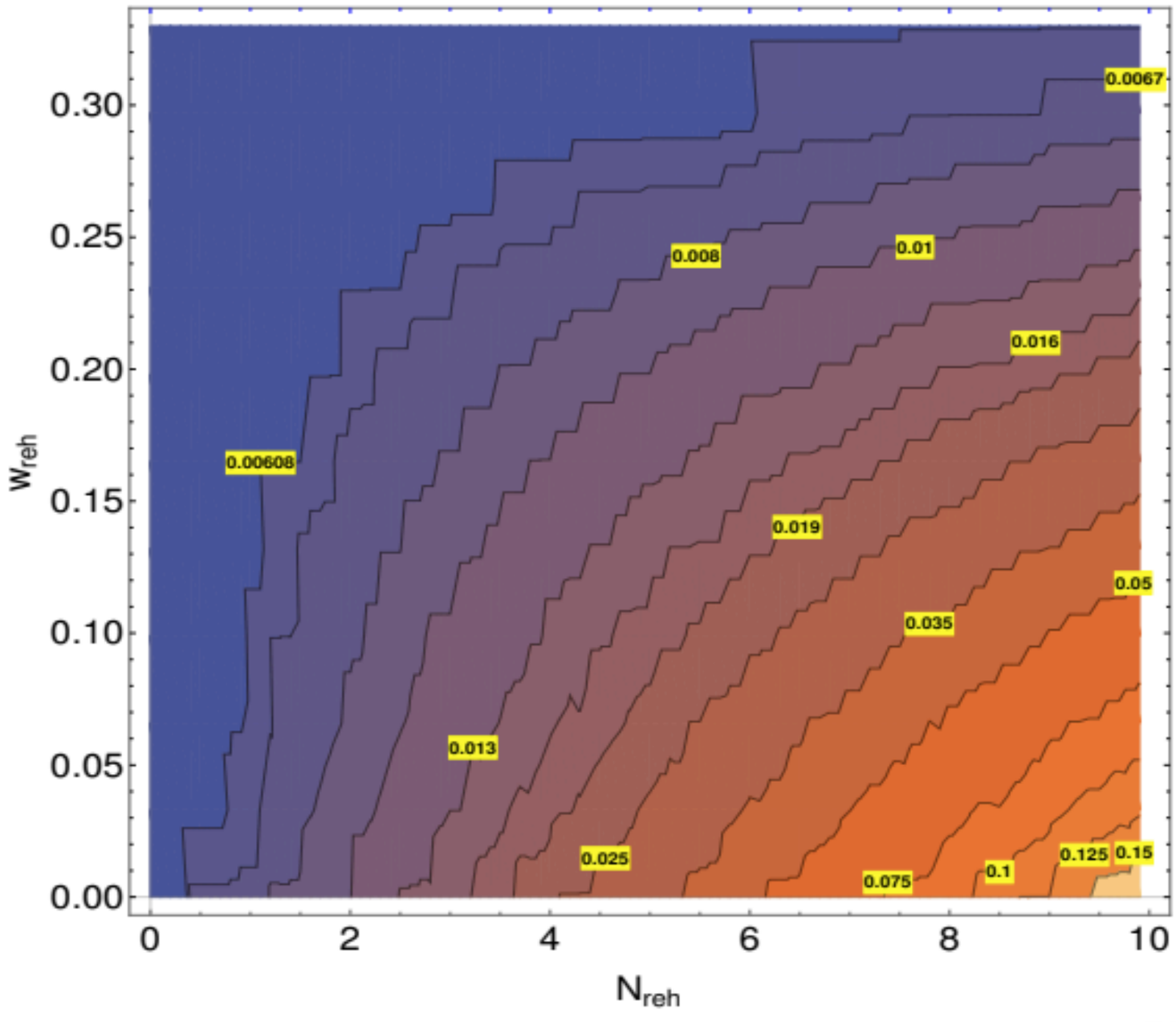

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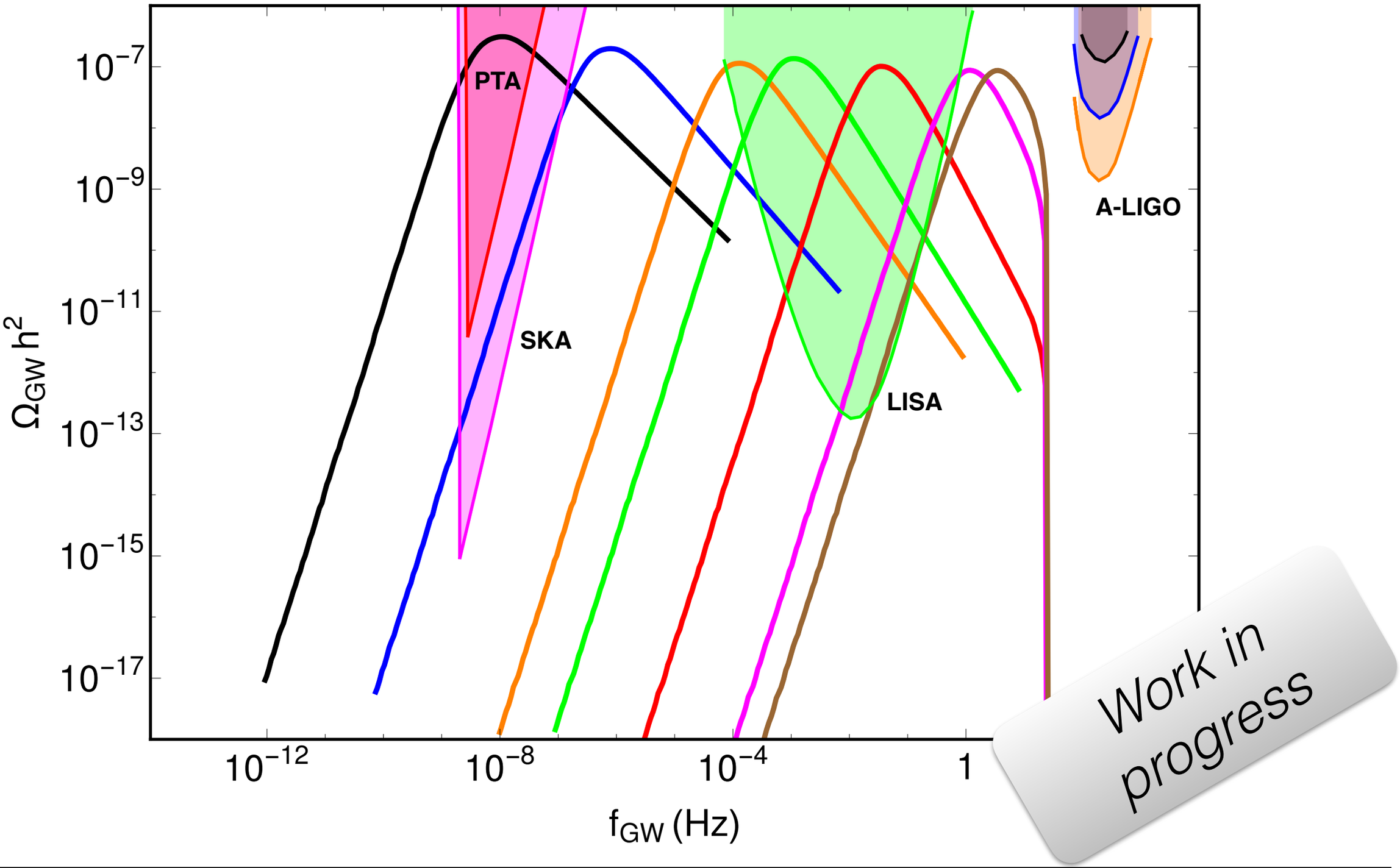
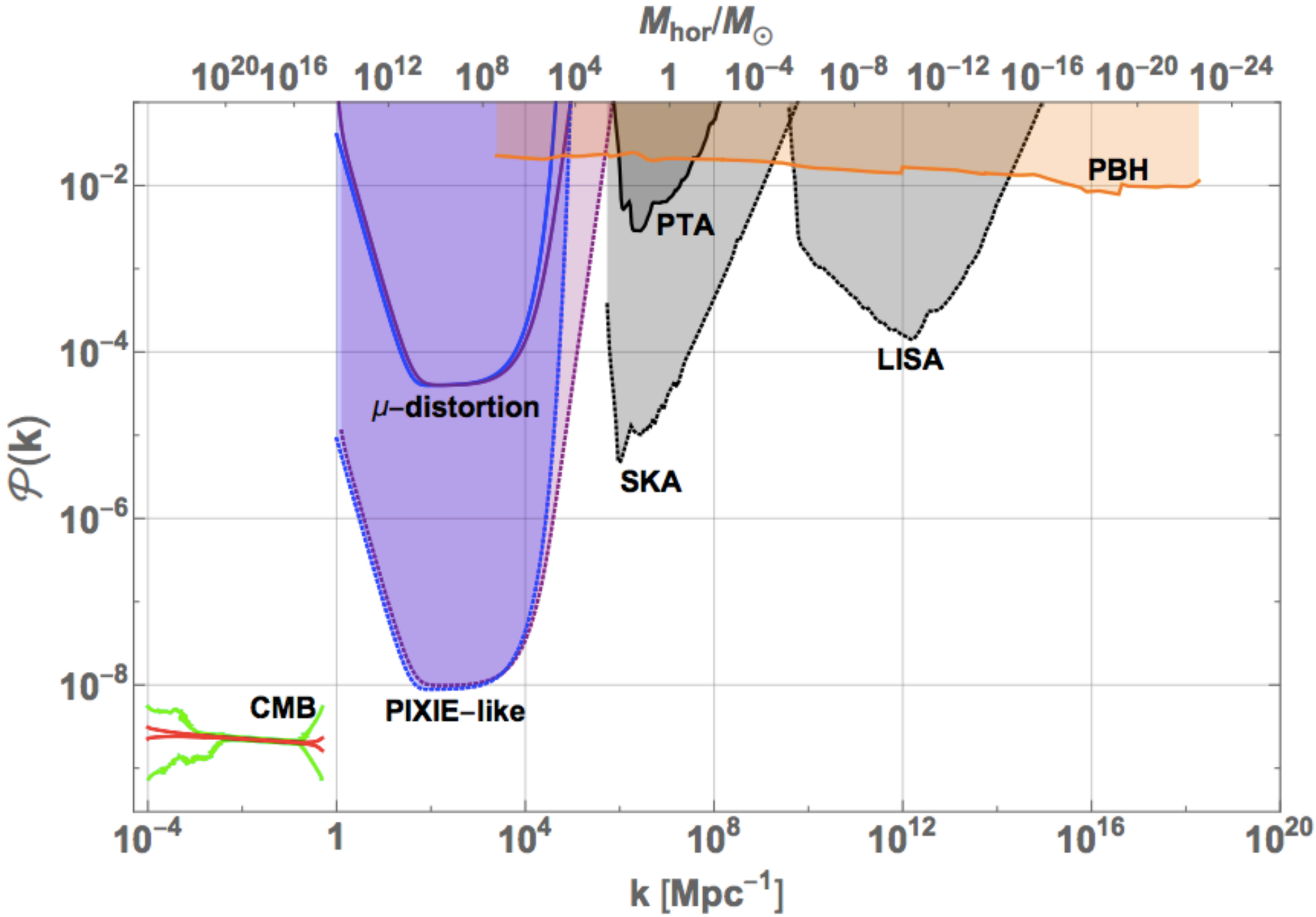
Induced secondary GWs



Work in progress

Future constraints on small scales



Byrnes, Cole & Patil 2018

Conclusions and summary

- PBHs are very novel candidates for CDM in the universe
- Inflection point inflationary models most useful to generate PBH - model dependent results
- We have developed a numerical code which calculates the primordial spectra and PBH mass fraction as analytic calculations are in general not possible
- Very useful to probe the small scale dynamics during inflation
- Interesting byproduct imprints such as induced gravitational waves on scales probed by PTA and LISA
- PBH mass fraction affected by primordial NG and quantum duffusion during the ultra slow roll phase — yet to understand in this scenario

Thank you !