Primordial Black Holes Extended Mass Distributions as Dark Matter

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Research on PBHs

Proposed by Zel'dovich, 1966

- Produced by the collapse of an overdense region in the very early Universe

First studies by Stephen Hawking

- Minimum mass for PBH $\sim 10^{-5}$ g, (1971)
- Mass evolution due to accretion (Hawking & Carr, 1974)

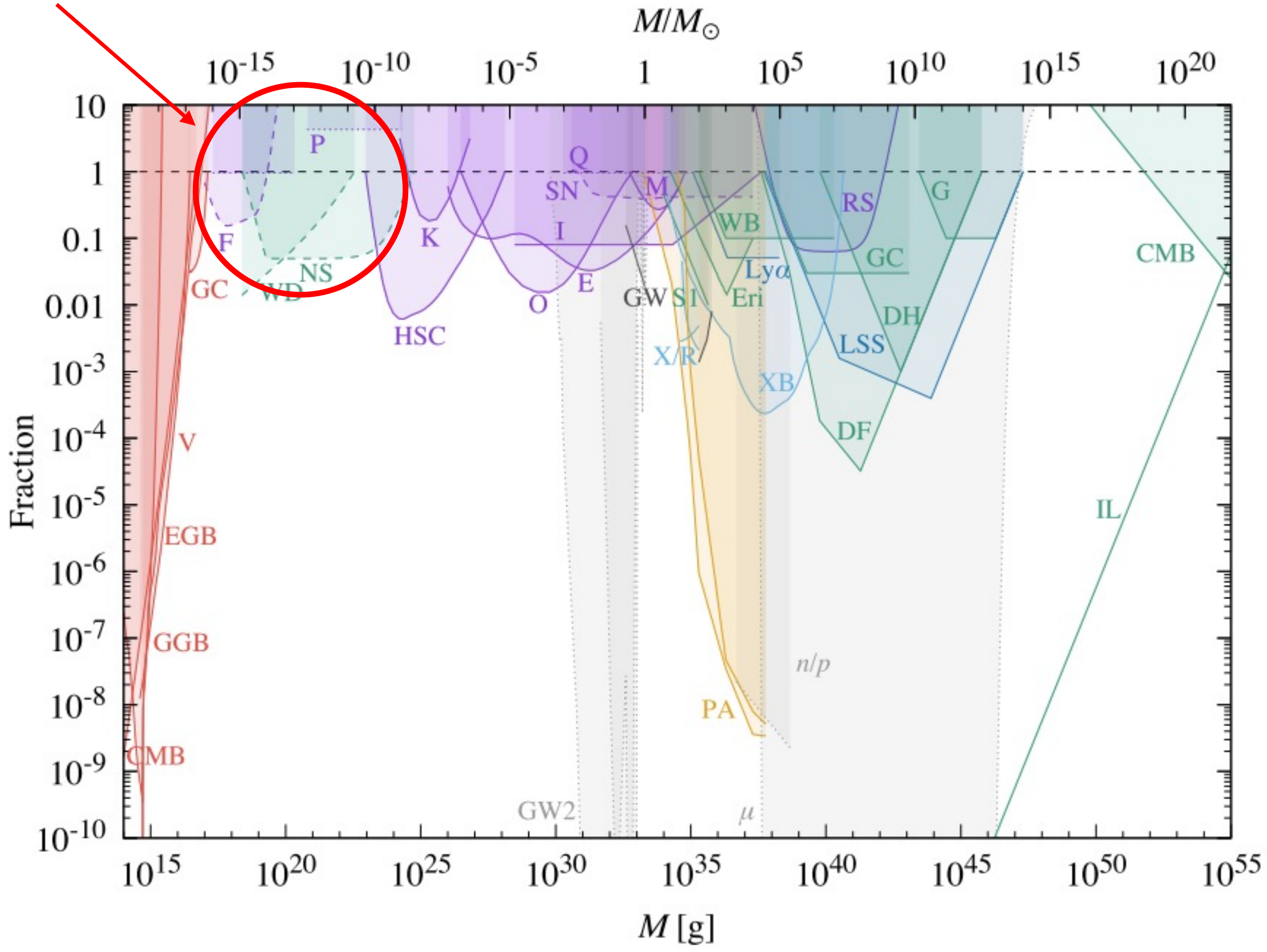
PBHs can have a wide range of masses

- $10^{-38}\ M_{\odot} < M_{PBH} < 10^{15}\ M_{\odot}$

Constraints on the PBH/DM fraction

$$f_{PBH} = \frac{\rho_{PBH,0}}{\rho_{DM,0}}$$

Interesting window to study at $10^{-15} \lesssim M \lesssim 10^{-10}\ M_{\odot}$



Monochromatic Mass Distributions! *B. Carr et al. 2020*

Primordial black hole extended mass functions

Primordial Power Spectrum:

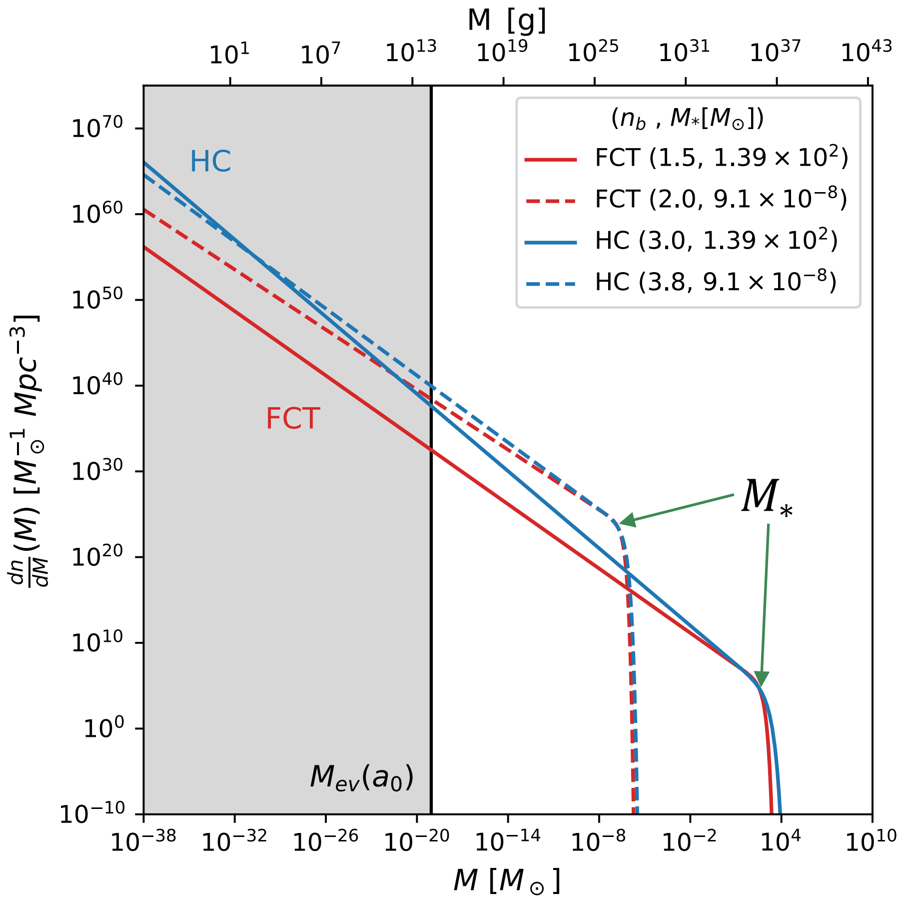
$$P(k) = A_s k^{n_s}$$

"Broken" Primordial Power Spectrum:

$$P(k) = \begin{cases} A_s k^{n_s}\ , k < k_{\mathrm{piv}} \\ A_s \epsilon k^{n_b}\ , k \geq k_{\mathrm{piv}} \end{cases}$$

Enhancement on small scales

$$k_{\mathrm{piv}} = 10\ \mathrm{Mpc}^{-1}$$



How can we translate the constraint on MMD to constraints on EMD?

Each constraint is related to an observable output

The outputs are assumed to be extensive on the number of objects (PBHs)

$$f_{PBH}(M) = \min\left(1, \frac{\text{Maximum Allowed Output}}{\text{Measured Output}}\right)$$

We define the normalized output function

$$g(M) = \frac{1}{f_{PBH}(M)}$$

An EMD can be interpreted as the sum of different monochromatic populations

$$\langle g(M) \rangle = \text{Average Output Function}$$

Averaged in the mass range where the observation for that constraint is sensible.

Weighted by the mass function

$$f_{eff} = \frac{1}{\langle g(M) \rangle}$$

Extra corrections must be included

Constraints on extended mass distribuions

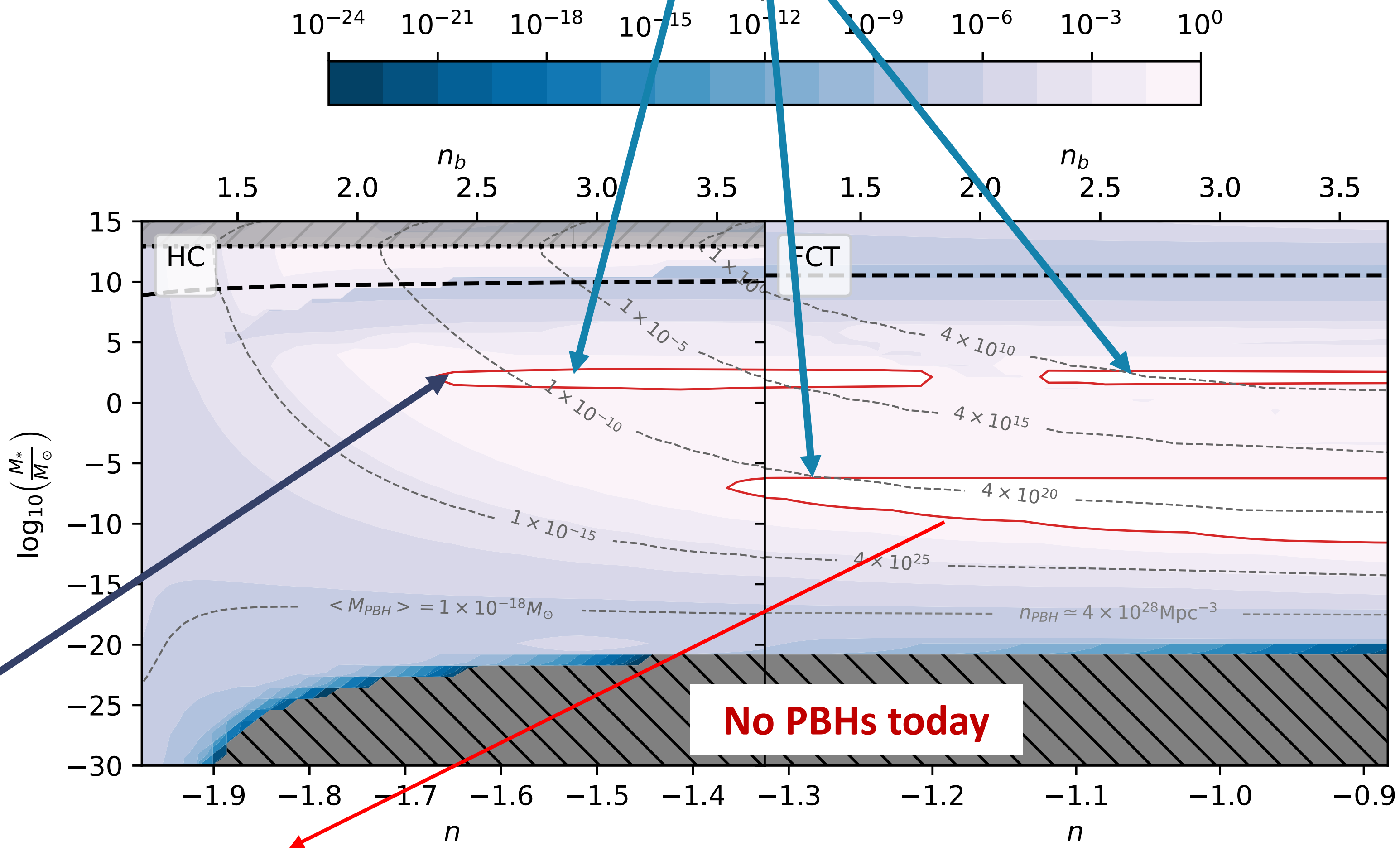
These EMD follow a Schechter form characterized by two parameters:

n → Slope

M_* → Characteristic cut-off mass

Interesting windows as they include PBHs with masses close to the ones detected by LIGO

Regions where DM can be totally in the form of PBHs



$< M >\sim 10^{-14} M_\odot$ In agreement with the MMD window