

PBHs

An unfortunate tale of misunderstandings

Cristiano Germani
(Icc, Barcelona)

In collaboration with:

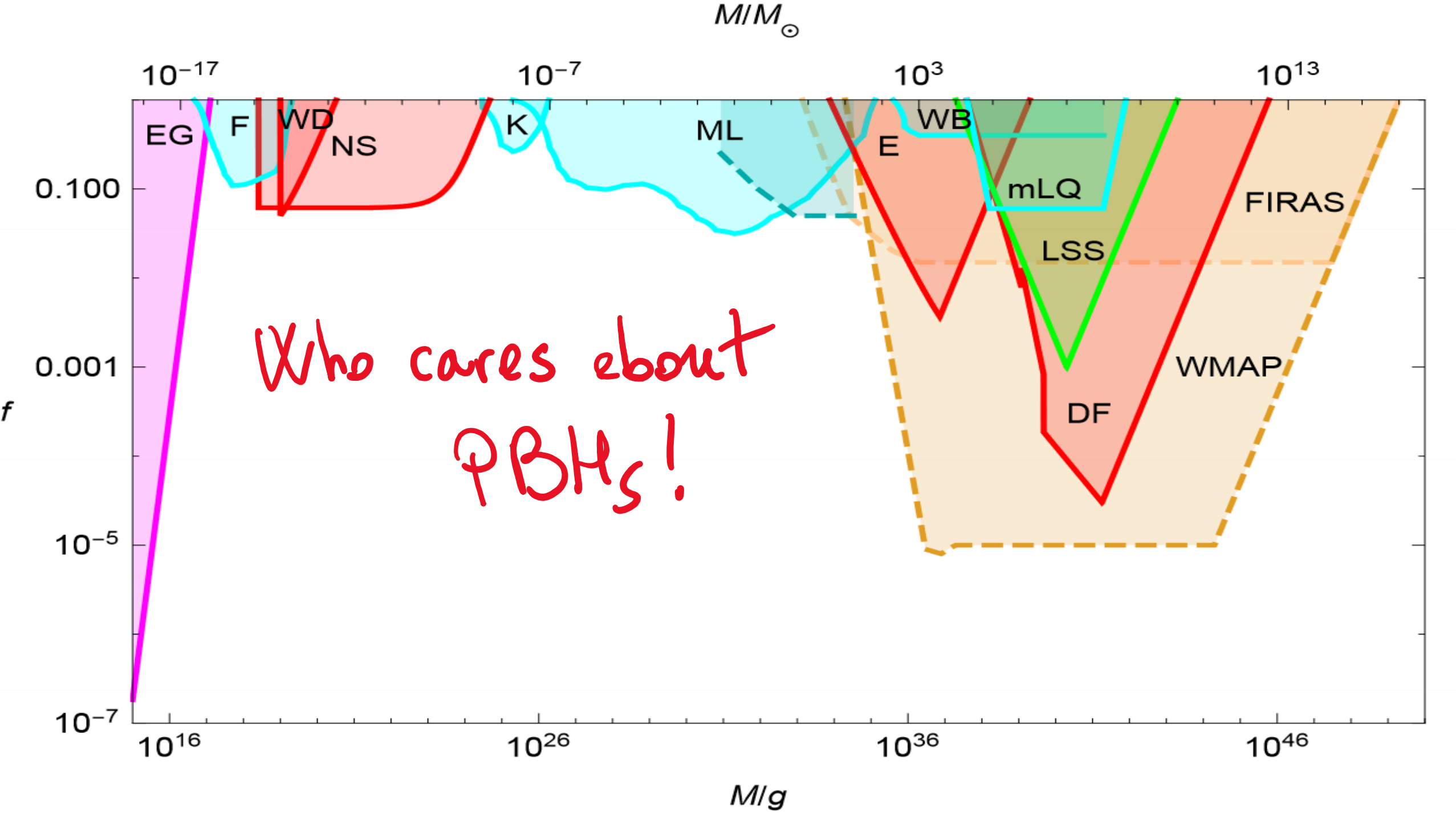
- Atal
- Cruces
- Musco
- Prokopec

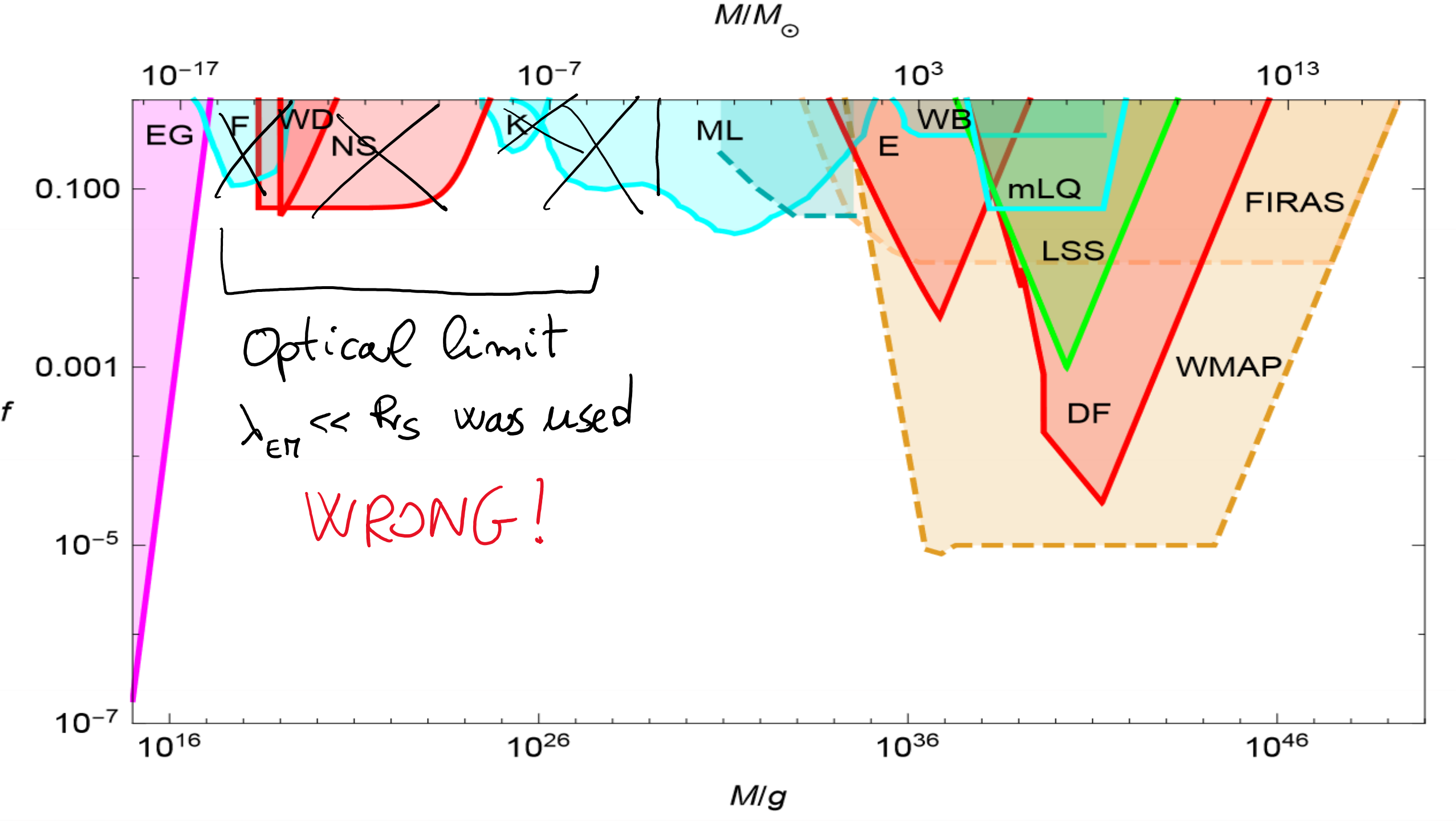
Mostly based on
1805.04087

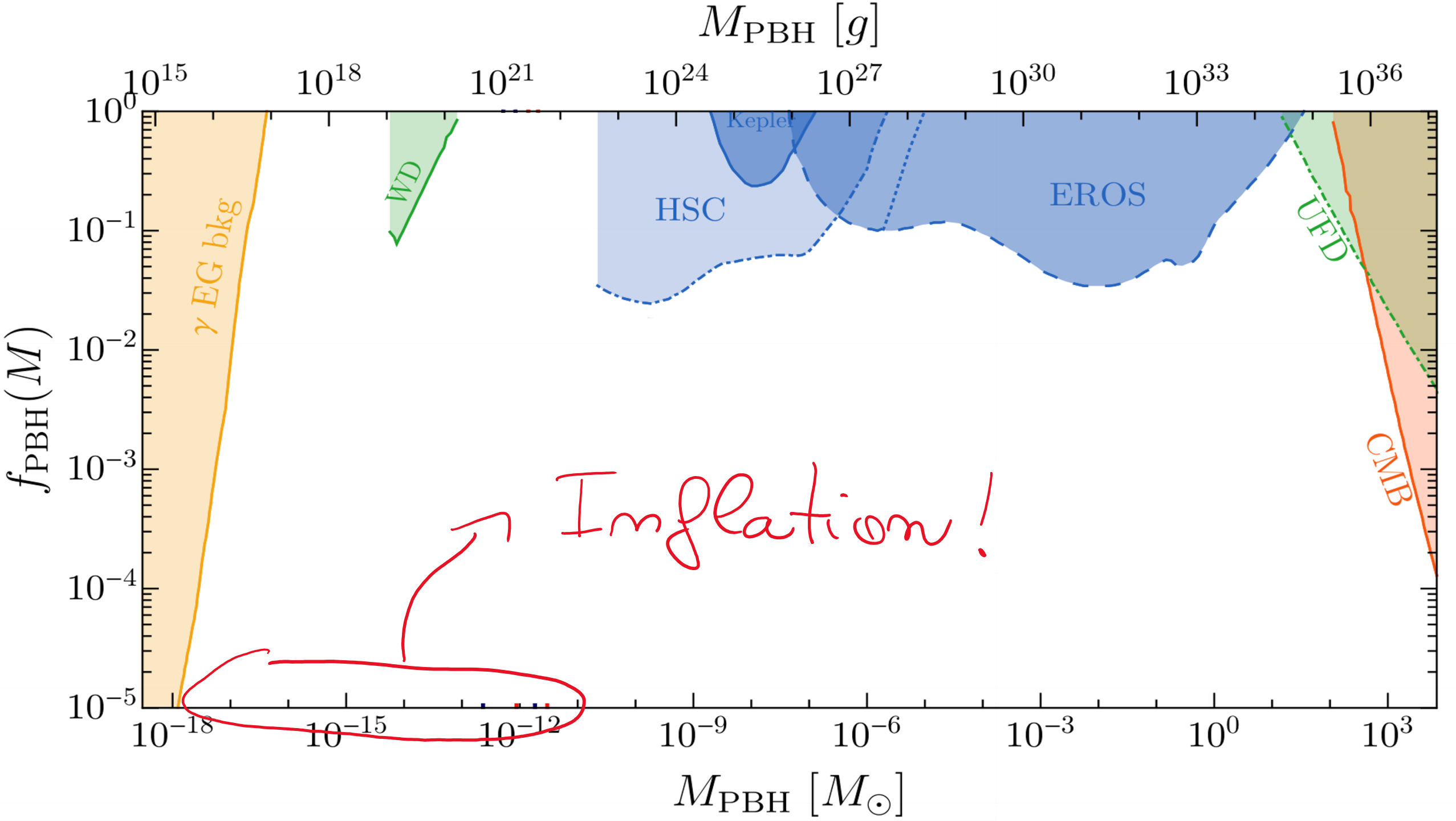
Section I :

Observational

Misunderstandings







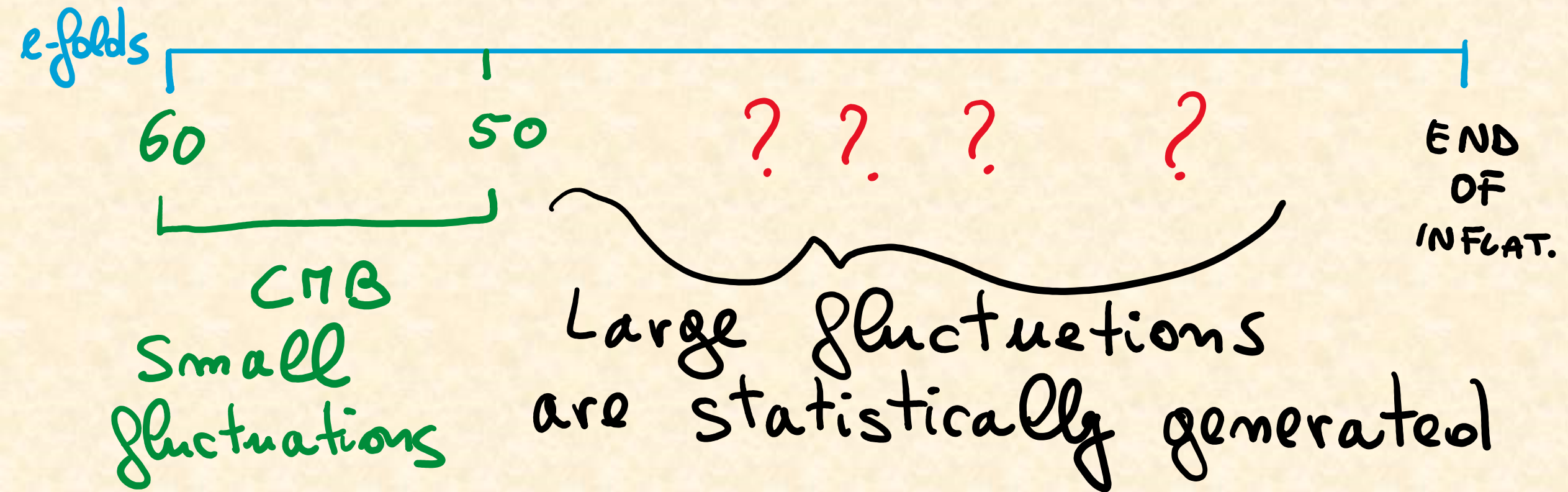
Section II :

Theoretical

Misunderstandings

What we do(m't) know

INFLATION



So

Large fluctuations



Gravitational collapse into PBH
(@ Horizon crossing)

So

Large

fluctuations



Gravitational collapse into PBH
(@ Horizon crossing)

What does that mean?

Before 1805

Grav. collapse
in FRW:

$$\# \approx \frac{1}{\delta_0} \left(\frac{1}{\delta_0} - 1 \right)$$

$$\delta_0 = 0.45$$



Before 1805

of course!

$$\left| \frac{\delta \rho_k}{\rho_b} \right| \geq 0.45 !$$

@Hor.X

Universal !

$k \equiv$ Fourier
mode of
perturbation

Grav. collapse
in FRW:

$$\# \approx \frac{1}{\delta_0}$$

$$\sim \sim \sim$$

$$\delta_0 = 0.45$$



Elementary Newton!

$$\frac{\delta \rho}{\rho} \approx \frac{4}{9} \frac{\nabla^2 \mathcal{R}}{a^2 H^2}$$

$\mathcal{R} \equiv$ curvature perturb.

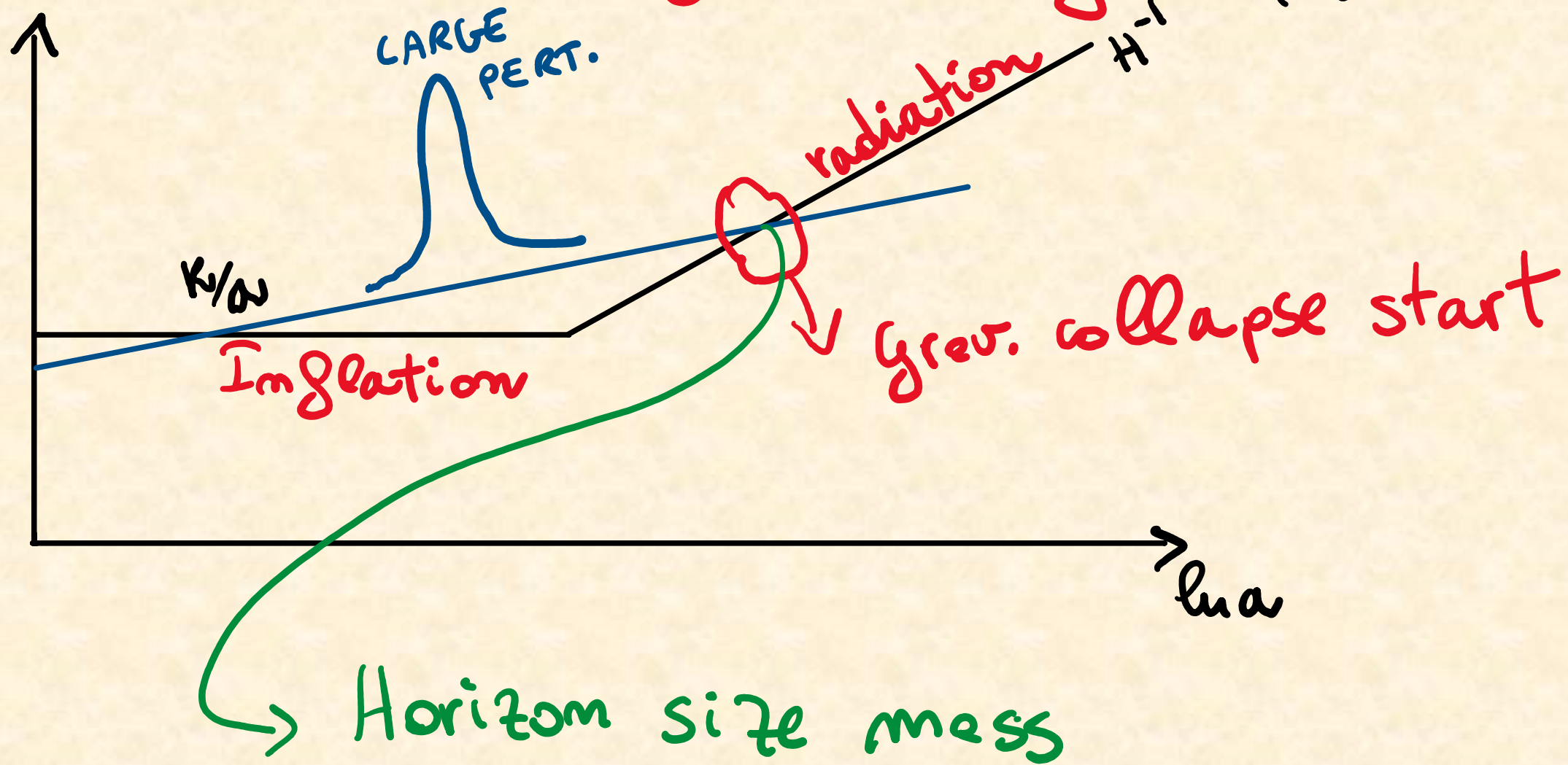


$$0.45 \leq \left. \frac{\delta \rho_k}{\rho} \right|_{\text{H or } x} \approx \frac{4}{9} \mathcal{R}_k \geq 1.1$$

($k = aH$)

A beautiful story

$$(ds^2 = -dt^2 + a^2 d\vec{x} \cdot d\vec{x})$$



Then the density of PBHs
is given by Press-Schechter

$$\frac{dN}{dV} \sim \int_{\nu_c}^{\infty} n(\nu) d\nu$$

$$\nu = \frac{\mathcal{R}}{\langle \mathcal{R} \mathcal{R} \rangle}$$

$$n \sim e^{-\frac{\nu^2}{2}}$$

$$\nu_c \sim \frac{\mathcal{R}_c}{\underbrace{\mathcal{P}}_{\text{Power spectrum}}} \sim \frac{1.1}{\mathcal{P}}$$

Power spectrum

Beautiful

BUT

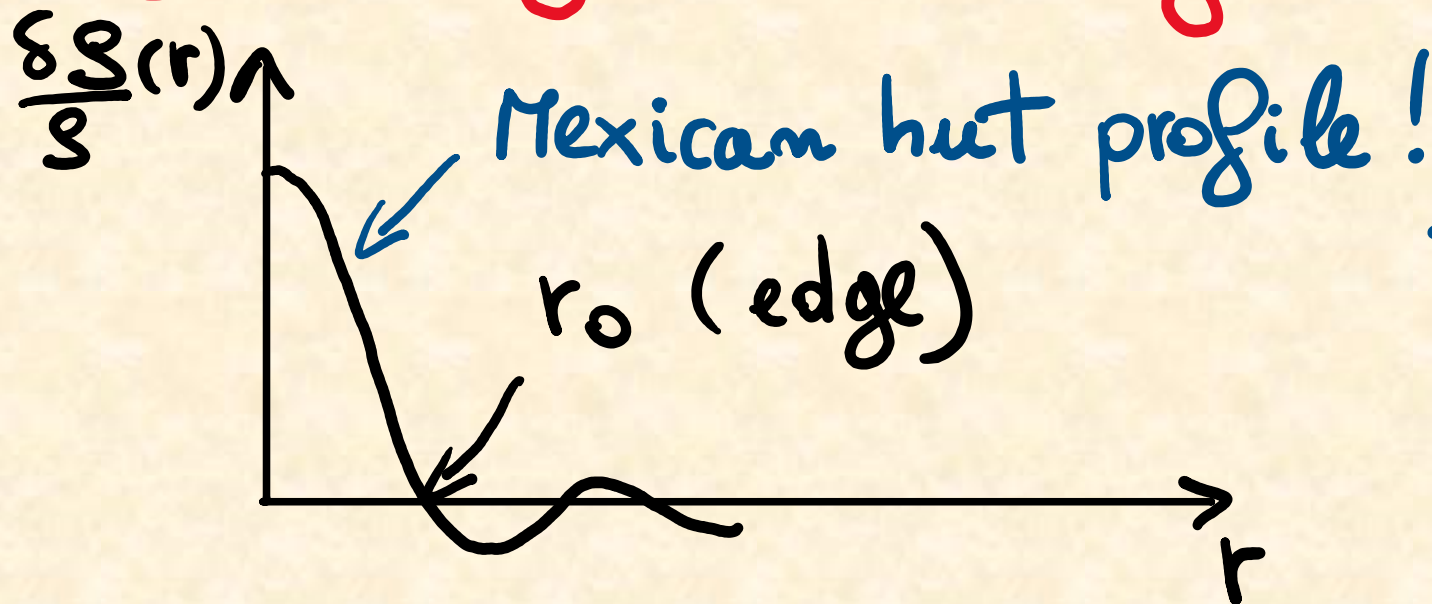
WRONG!

Story after 1805

I mistakes:

$$\delta(r) = \frac{\delta M}{M_b} \equiv \frac{1}{M_b} \int \delta \rho d$$

δ_0 given by Musco (before 2018*)



$$\delta_0 = \delta(r_0)$$

* Now a bit more sophisticated

So:

- Threshold (δ_0) has nothing to do with $\frac{\delta \rho_k}{\rho_b}$
- It is profile dependent $\Rightarrow$ No UNIVERSAL!

Threshold is a real space quantity



The statistic of PBHs cannot be related to $\mathcal{Q}$ (this guy is shift invariant)



II Mistake : Press-Schechter cannot be used!

1805 $\rightarrow$

* Well slightly different...

Press-Schechter $\rightarrow$ Peak theory

Shortly
still* $n \sim e^{-\frac{\nu^2}{2}}$

$$\frac{dN}{dV} = \int_{\nu_c}^{\infty} n(\nu) d\nu$$

But - - -

$$\nu = \frac{\Delta(0)}{\sigma_{\Delta}}$$

$$\Delta(r) = \frac{\langle \delta s(r) \rangle}{s_b}, \quad \sigma_{\Delta}^2 = \langle \Delta^2 \rangle$$

Not at the edge!



Profile dependence of the
Threshold

Not at all UNIVERSAL!

(CG, Musco)

Bad news

with the correct statistics :

There are no models of single field
inflation producing enough PBHs

(CG, ATAL)

Good News!

Work for everyone:

- Find an inflation model producing enough PBH
- Discover them via lensing!

Thanks!