Large scale cosmic perturbation from evaporation of primordial black hole

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Beauty of inflation scenario

Light scalar fields in general obtain fluctuations

$$\delta\sigma \simeq H/(2\pi)$$

$\delta\sigma \rightarrow \delta\rho/\rho$ via

- Inflaton : $\delta t_{\rm inflation}$
- Curvaton : δV
- Modulated Reheating : $\delta t_{\rm reheating}$

A mechanism we propose

A mechanism universal in the universe
once dominated by Primordial Black Holes

- Blue tilted perturbation generated by inflaton
- Preheating
- Collapse of topological defects

Basic Idea

Assume

- A scalar field σ
- A fermion field ψ
- A Yukawa interaction $\mathcal{L}_{\rm int} = y\sigma\psi\psi$

Familiar situation for spontaneous symmetry breaking

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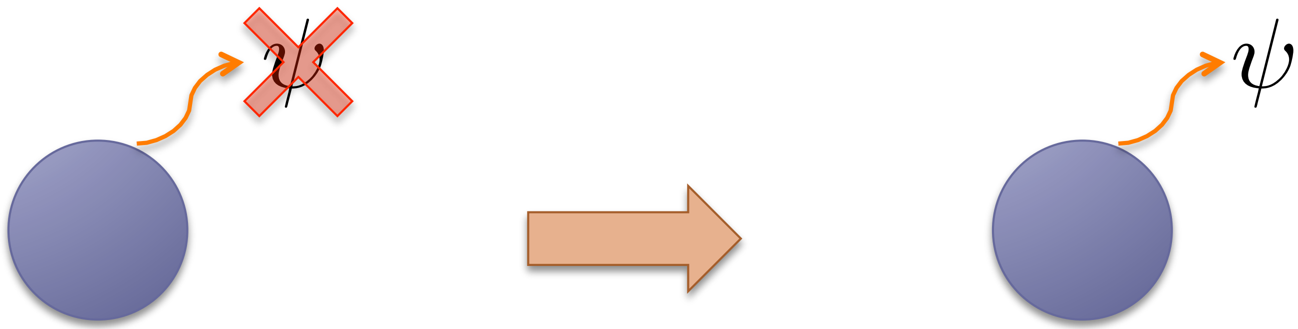
$$\delta m_\psi = y\delta\sigma$$

Basic Idea

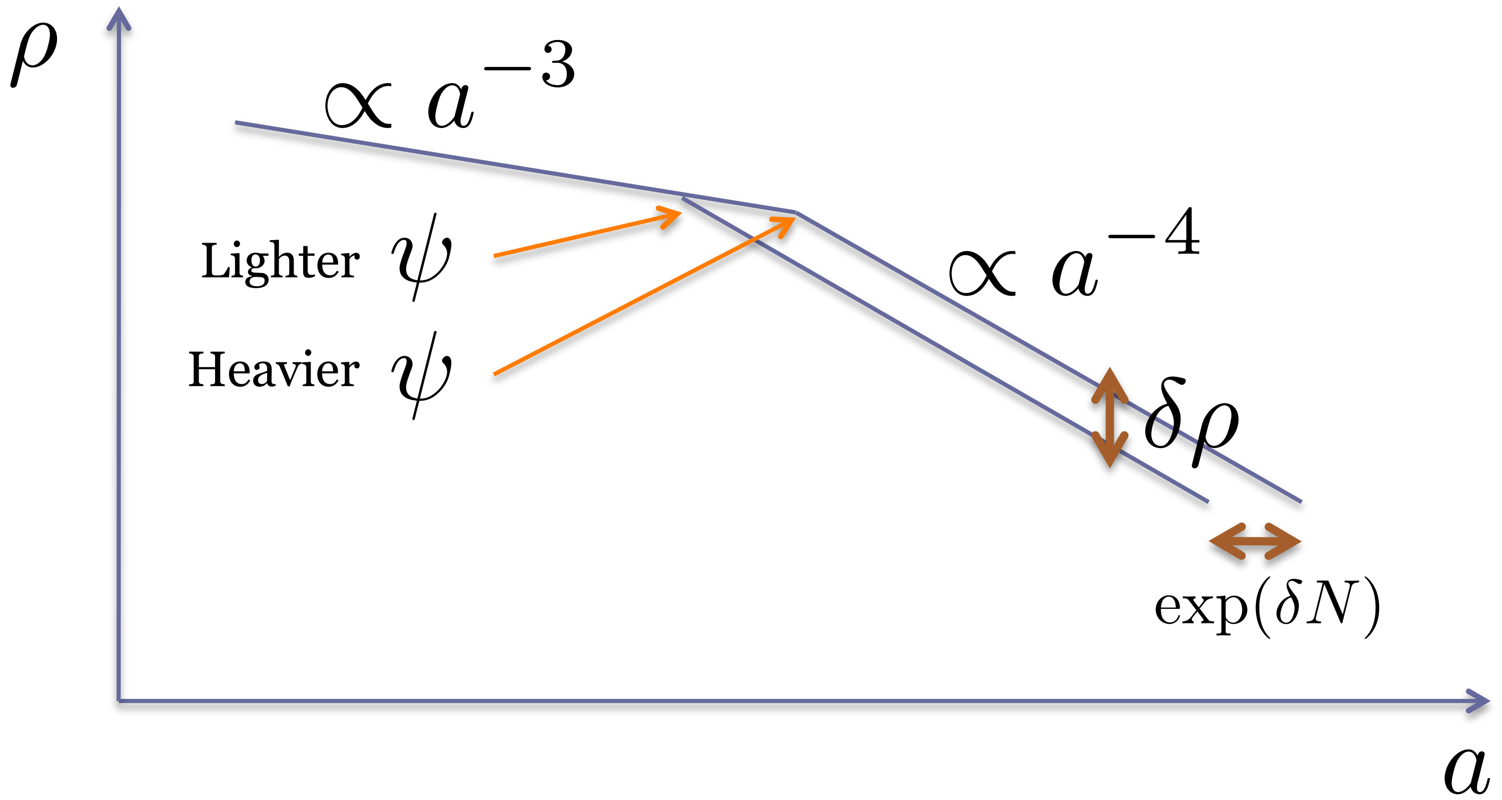
PBHs radiate particles with $T_{\rm HAW} = M_{pl}^2/M_{\rm BH}$

Assume $T_{\rm HAW} < m_\psi = y < \sigma >$ initially

$M_{\rm BH} \searrow \quad \Rightarrow \quad T_{\rm HAW} \nearrow \quad \Rightarrow$ Begin to radiate ψ



Fluctuation of evaporation



$$\delta\sigma \Rightarrow \delta m_\psi \Rightarrow \delta t_{\rm eva} \Rightarrow \zeta$$

$\sigma, \ \psi$ do not have to couple to any other particles

Calculations

Solve $\frac{\mathrm{d}}{\mathrm{d}t} M_{\mathrm{BH}} = -\frac{\pi}{480} g_* \frac{M_{pl}^4}{M_{\mathrm{BH}}^2}$ with $g_* = \begin{cases} g_0 & (T_{\mathrm{HAW}} < m_\psi) \\ g_0 + g_\psi & (T_{\mathrm{HAW}} > m_\psi) \end{cases}$

$$t_{\mathrm{eva}} = \mathrm{const.} \times \left[1 - \left(\frac{T_i}{m_\psi} \right)^3 \frac{g_\psi}{g_0 + g_\psi} \right]$$

$$\zeta = \frac{\delta t_{\mathrm{eva}}}{6 t_{\mathrm{eva}}} = \frac{1}{2} \frac{g_\psi}{g_0 + g_\psi} \left(\frac{T_i}{m_\psi} \right)^3 \frac{\delta \sigma}{\sigma}$$

$$\mathcal{P}_\zeta^{1/2} = \frac{y}{\pi} \frac{g_\psi}{g_0 + g_\psi} \frac{T_i^3 H_{\mathrm{inf}}}{m_\psi^4}$$

Is it consistent with the observation?

Ex. PBHs are produced right after the inflation

$$M_i \simeq 0.2 \times \frac{4\pi H_{\rm inf}^{-3}}{3} \times 3H_{\rm inf}^2 M_{pl}^2 \simeq 2.5\frac{M_{pl}^2}{H_{\rm inf}} = \frac{M_{pl}^2}{T_i}$$

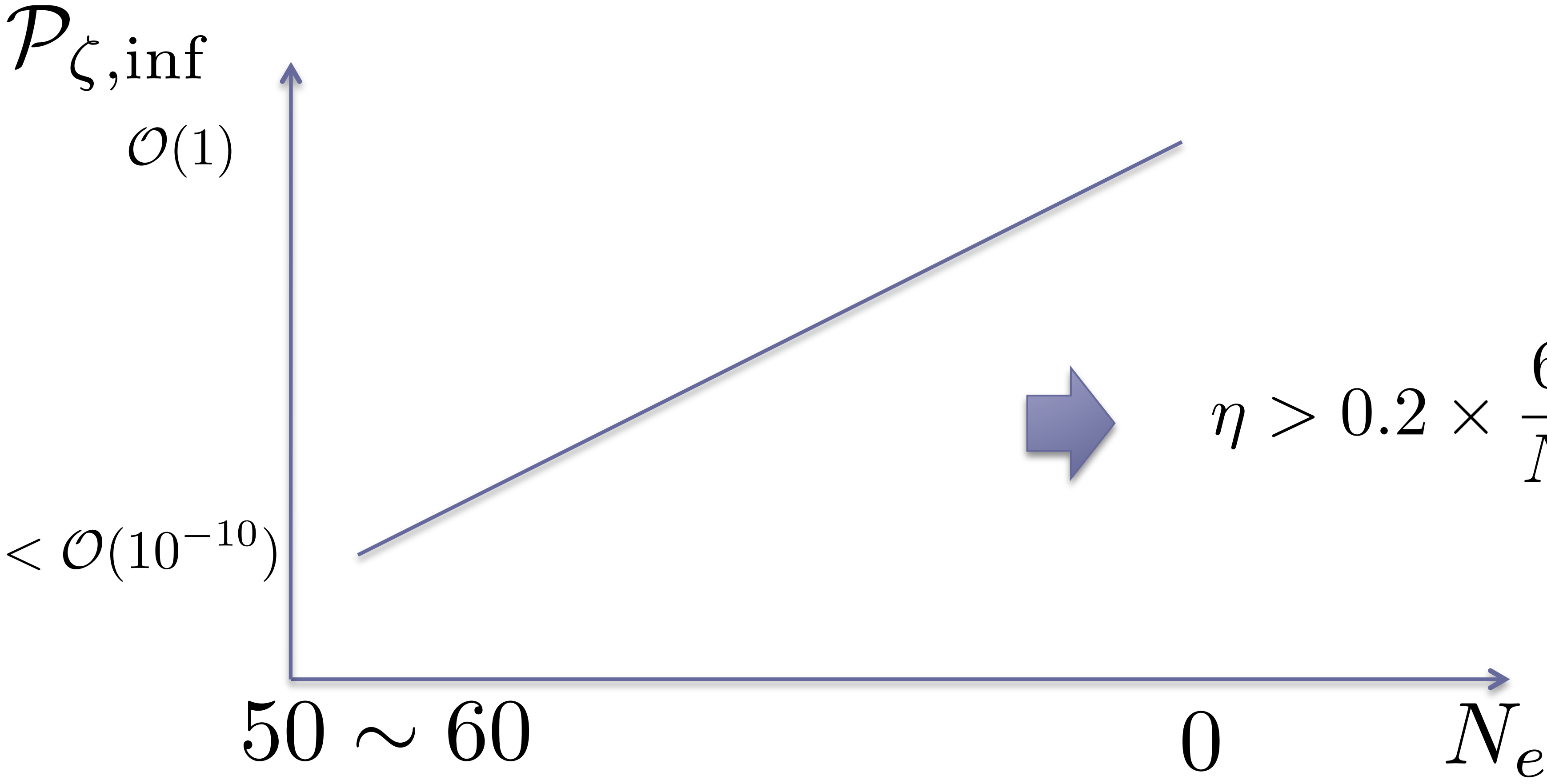
$$\mathcal{P}_\zeta^{1/2} = \frac{y}{\pi}\frac{g_\psi}{g_0+g_\psi}\frac{T_i^3 H_{\rm inf}}{m_\psi^4}$$

$$(g_0 \simeq 100, g_\psi \ll g_0)$$

$$\simeq 10^{-5} \times \frac{y}{0.3} g_\psi \left(\frac{H_{\rm inf}}{m_\psi}\right)^4$$

Imprecation to running spectral index

Assume that PBHs are generated simply due to a Blue-tilted perturbation by an inflaton field



$$\eta > 0.2 \times \frac{60}{N_*}$$

Imprecation to running spectral index

$$\eta > 0.2 \times \frac{60}{N_*}$$

$$n_s = 1 - 2\epsilon \simeq 0.96$$

$$\frac{\mathrm{d}n_s}{\mathrm{dln}k} \simeq -4\epsilon\eta < -0.01\frac{60}{N_*}$$

Summary

- New mechanism for generating cosmic perturbation is proposed
- Universal in PBH dominated universe
- Applicable to Hidden sector models
- Large running spectral index is easily obtained

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