

Title: Constraining initial state non-gaussianity via backreaction

Date: Mar 07, 2008 05:30 PM

URL: <http://pirsa.org/08030048>

Abstract:

Cosmology (SGC)

June 15

inflation

$$\bar{n}_Q$$

1. Interactions & inflation

3

2

4

5

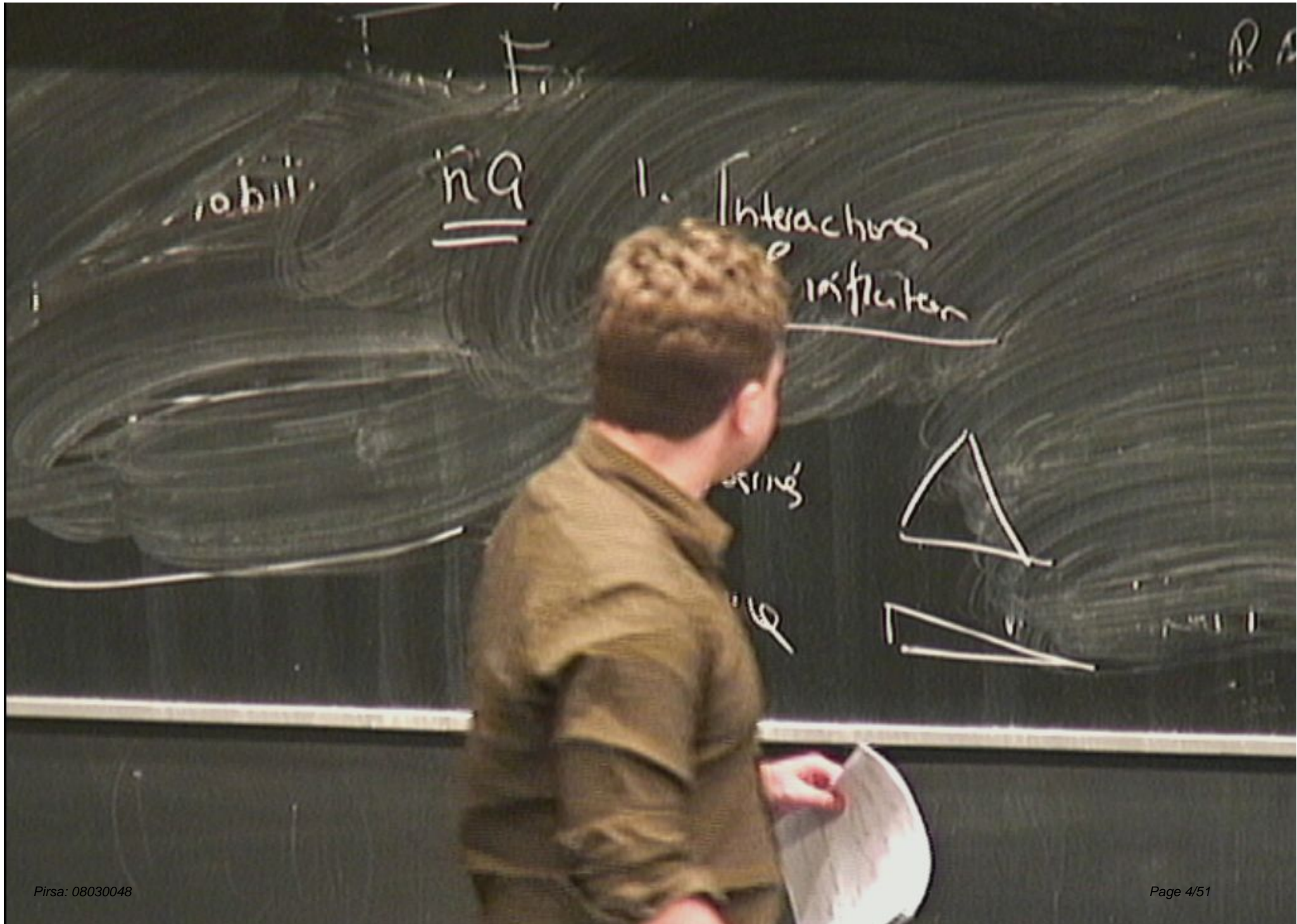
orbit

$$\underline{\underline{\hbar\eta}}$$

1. Interactions & inflation

Hamilton crossing





robil.

nq

1. Interacting
inflation



robil

nq

1. Interactions
& inflation

Horizon crossing

Slip: thudle



$$\psi(z, t) = e^{-\int_{z_0}^z \sqrt{12} \frac{m}{\hbar} dz} e^{-\frac{m g z^2}{2 \hbar^2}}$$

511

↓

Wahl

$$\psi(\vec{z}, t) = e^{-\int_{\vec{z}} \sqrt{12} \vec{z}} e^{-\frac{t}{M_{pl}}}$$

$$\langle \vec{z} \vec{z} \vec{z} \rangle$$

$$\vec{z} = \frac{H \delta \phi}{\dot{\phi}} = \frac{\delta \phi}{\sqrt{6} M_{pl}}$$

problem

$$\psi(\vec{z}, t) = e^{-\int_{z_0}^z \sqrt{2E} dz} e^{-\frac{i}{\hbar} \int_{z_0}^z \sqrt{2E} dz} \uparrow \uparrow \uparrow$$

$$\psi(z) \sim e^{-\int \sqrt{2E} dz}$$

$$\vec{z} = \frac{\hbar \delta \phi}{\phi} = \frac{\delta \phi}{\sqrt{e} M_{pl}}$$

$$\psi(\vec{z}, t) = e^{-\int_{\vec{z}}^{\vec{z}'} \sqrt{2} \vec{z}} e^{-\frac{1}{2} \vec{z}^2}$$

$$\langle \vec{z} \vec{z} \vec{z} \rangle$$

$$\frac{\langle \psi | T^{\mu\nu} | \psi \rangle}{\langle \psi | \psi \rangle} < \frac{V_{inf}}{V}$$

$$< \frac{H^2 M_{pl}^2}{M_{pl}^2} \rangle$$

$$\vec{z} = \frac{H \delta \phi}{\dot{\phi}} = \frac{\delta \phi}{\sqrt{\epsilon} M_{pl}}$$

$$\psi(\vec{z}, t) = e^{-\int_{z_0}^z \sqrt{2E} dz} e^{-\frac{i}{\hbar} \int_{z_0}^z \sqrt{2E} dz}$$

$$\langle \psi | T^x | \psi \rangle$$

$$\langle V_{inf} \rangle$$

$$\langle H^2 M_{pl}^2 \rangle$$

$$\vec{z} = \frac{\hbar \delta \phi}{\delta \phi} = \frac{\delta \phi}{\sqrt{2} M_{pl}}$$

$$\text{Slur } N_{eff} < 70$$

$$\frac{h}{2m} = M_{pl} \sim M_{pl}$$

$$\psi(\vec{z}, t) = e^{-\int_{\vec{z}} \sqrt{V} dz} e^{-\frac{1}{2} \vec{z}^T \vec{z}}$$

$$\langle \vec{z} | \vec{z} \rangle$$

$$\vec{z} = \frac{H \delta \phi}{\delta \phi} = \frac{\delta \phi}{\sqrt{G} M_{pl}}$$

$$\frac{\langle \psi | T^{\mu\nu} | \psi \rangle}{\langle \psi | \psi \rangle} < V_{inf}$$

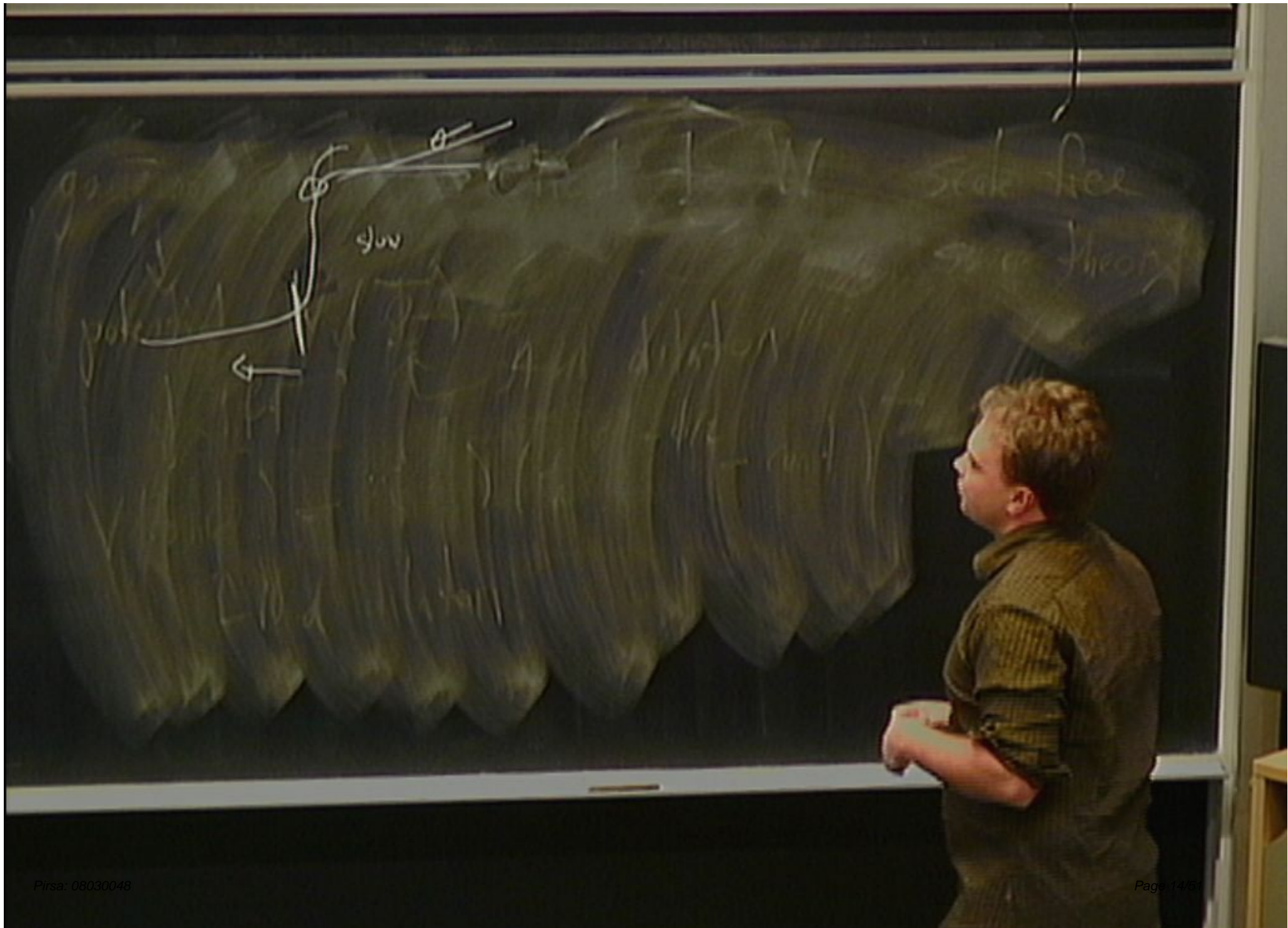
$$\frac{S_{eff}}{M_{pl}^2} < H^2 M_{pl}^2$$

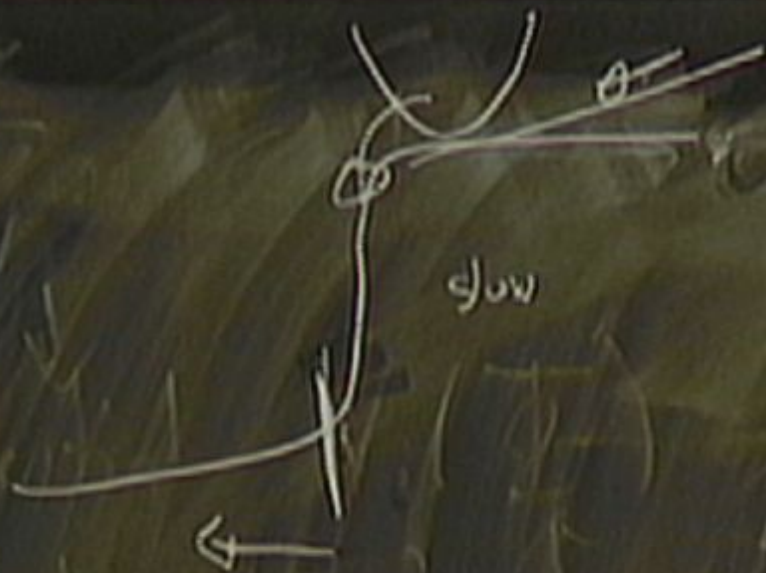
$$\text{Slow Roll } N_{eff} < 70$$

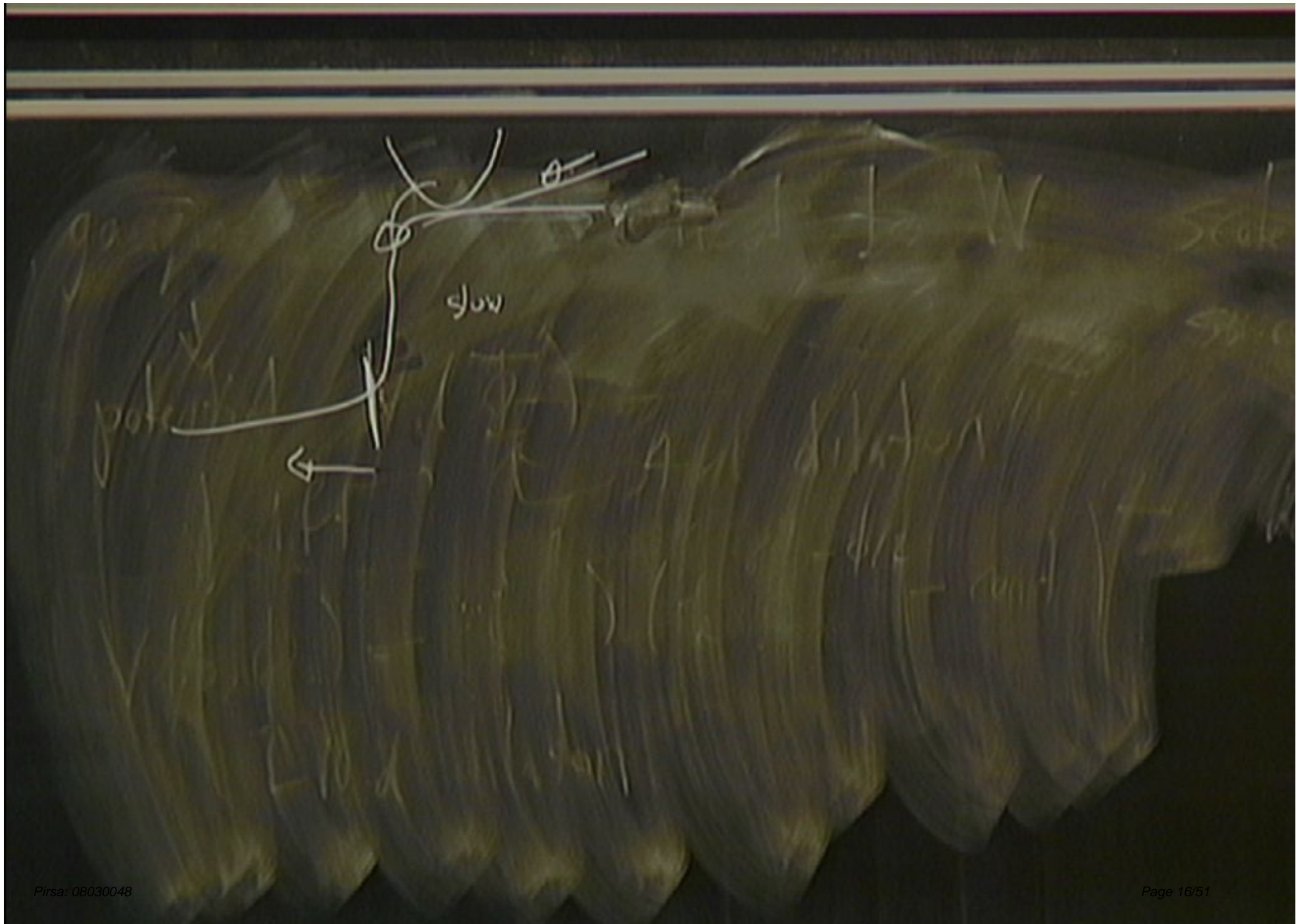
$$\frac{H}{M_{pl}} = M_{eff} \sim M_{pl}$$











Outline

$$p = \delta \dot{\phi}^2$$

$$\frac{1}{2} \sum_{\mathbf{k}} \omega_{\mathbf{k}}^2$$

Superspace

Outline

- 1
- 2
- 3
- 4

$$p = \delta \dot{\phi}^2 \approx \frac{1}{2} \frac{M_c^2}{\rho_L} \dot{\phi}^2$$

Classical Background

Significance

at line

$$\rho = \dot{\phi}^2 \approx \frac{M_{pl}^2}{M_{pl}^2}$$

1. Classical Background

$$\rho_M = H^2 M_{pl}^2$$

at line

$$p = \dot{\phi}^2 = \frac{1}{M_{pl}^2} \dot{w}^2$$

1. Classical background

$$\rho_M = H^2 M_{pl}^2$$

$$\rho_{\text{eff}} = \rho + \frac{1}{2} \dot{\phi}^2$$

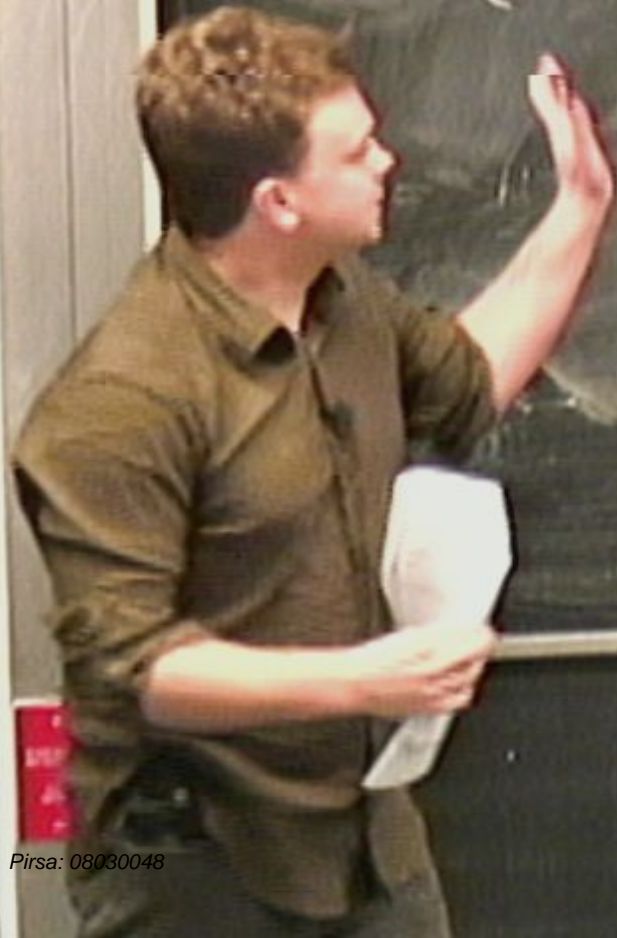
Super Hubble

2 Quanten/gravitation

$$\psi = \frac{1}{a} e^{-i k z}$$

$$< V_{inf} >$$

$$< H^2 M_{pl}^2 >$$



2 Quanten/perturbations

$$\psi \approx \frac{1}{a} e^{-iEt/\hbar}$$

$W = \text{constant}$

$$< \frac{V_{\text{inf}}}{c^2}$$

$$< \frac{H^2 M_{\text{pl}}^2}{c^2}$$

2 Quantum/perturbations

h_{max} $\vec{\zeta} = \frac{1}{a} e^{-i k \eta}$

$W = \text{constant}$

$< \frac{V_{\text{inf}}}{c^2}$

$< \frac{H^2 M_{\text{pl}}^2}{c^2}$



2 Quantum / probability

$$k > k_{crit} \quad \xi = \frac{1}{\alpha} e^{-\alpha |z|}$$

$W = \text{constant}$

$$k < k_{crit} \quad \xi = \text{const}$$

$< V_{inf}$
 $< H^2 M$

2 Quantum probabilities

$k > k_{crit}$ $\xi = \frac{1}{\alpha} e^{-\alpha |z|}$

$W = \text{constant}$

$k < k_{crit}$ $\xi = \text{const} = e^{-N^* |z|}$

SS

2 Quanten/periodization

$$k > k_{crit} \quad \xi = \frac{1}{a} e^{-i k z}$$

$W = \text{constant}$

$k < k_{crit}$

$$\xi = \text{const}$$

$$= e^{-N^*} \xi^*$$

$< V_{inf}$

$< H^2 M$

SS

2 Quantum fluctuations

$$k > k_{\text{crit}} \quad \xi = \frac{1}{\alpha} e^{-\alpha/k}$$

$$W = \text{constant}$$

$$k < k_{\text{crit}} \quad \xi = \text{const}$$

$$= e^{-N^*} \xi^*$$

$$\xi$$

=

$$\left(\frac{\xi^*}{\xi} \right)^{N^*}$$

$$\xi^* = \frac{1}{\alpha}$$



$$T = \frac{GM \sum_{i=1}^n \frac{1}{r_i^2}}{M \rho L}$$

CAUTION
 Please do not touch the board
 as it may be hot or cold.
 Please do not write on the board
 with anything other than chalk.
 Thank you.



$$T = \frac{GM_* \sum_*^2}{H^2 M_{pl}^2} < H^2 M_{pl}^2$$

$$\sum_* = \frac{\int d\alpha}{\sqrt{E M_*}}$$

$$\sum_* < \frac{H M_{pl}^2}{\sqrt{E M_*}}$$



$$T = M_p^2 \epsilon M_{*}^2 \sum_{*}^2 < H^2 M_{pl}^2$$

$$\sum = \frac{\int d\alpha}{\sqrt{\epsilon} M_{pl}}$$

$$\sum_{*} < \frac{H M_{pl}}{\sqrt{\epsilon} M_{*}}$$

CAUTION
 Beware of falling objects from above
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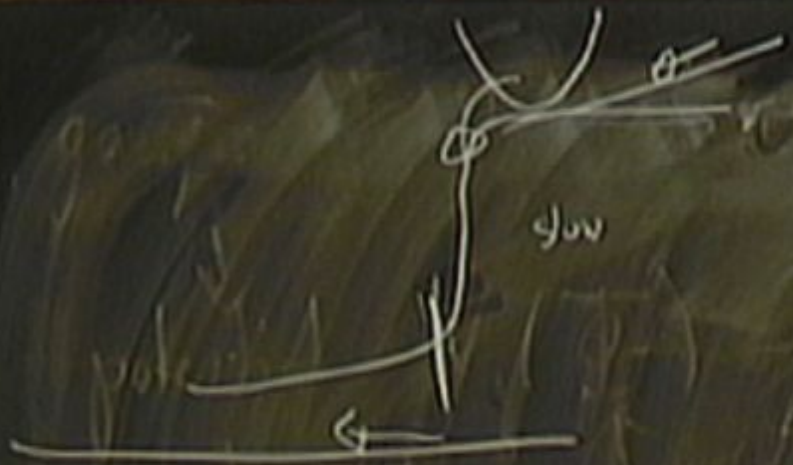
guy



$$T = M_p^2 \left(\frac{2}{GM_x} \right)^2 < H^2 M_{pl}^2$$

$$\left(\frac{2}{GM_x} \right)^2 < \frac{H^2 M_{pl}^2}{\sqrt{E} M_{pl}}$$

$$\frac{2}{GM_x} = \frac{2}{\sqrt{E} M_{pl}}$$

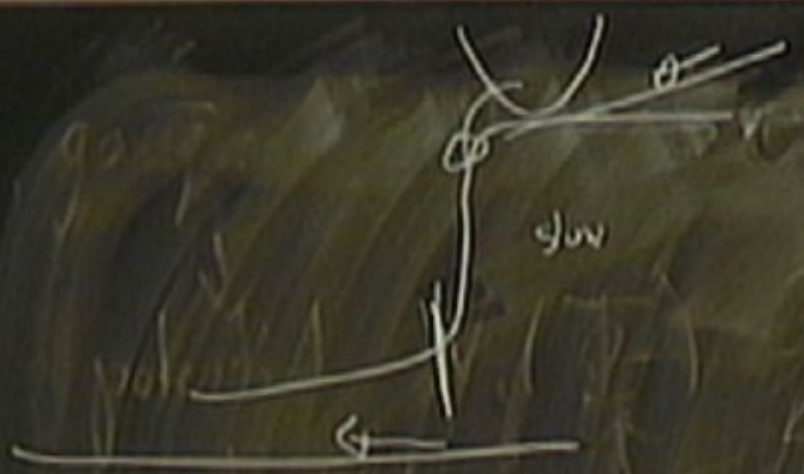


$$\vec{z}_H = \left(\frac{H}{H_*} \right) \frac{H}{\sqrt{E M_{pl}}} \sim \frac{H^2}{\sqrt{E M_{pl}^2}}$$

$$T = M_p^2 \frac{2 \cdot 2}{E M_{pl}^2} < H^2 M_{pl}^2$$

$$\vec{z} = \frac{H}{\sqrt{E M_{pl}}}$$

$$\vec{z}_* < \frac{H}{\sqrt{E M_{pl}}}$$



$$\Sigma_H = \left(\frac{H}{\sqrt{E M_{xx}}} \right) \frac{H}{\sqrt{E M_{xx}}} \sim \frac{H^2}{\sqrt{E M_{xx}^2}}$$

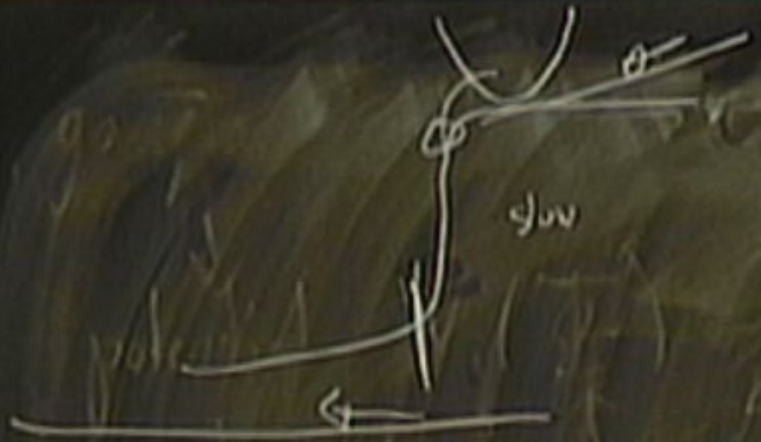
$$\Sigma_0 = \frac{H}{\sqrt{E M_{pl}}}$$

$$T = M_p^2 \frac{2}{E M_{xx}^2} \Sigma_x^2 < H^2 M_{pl}^2$$

$$\Sigma_x < \frac{H M_{pl}}{\sqrt{E M_{xx}}}$$

$$\frac{\delta P}{P} = \frac{H M_{pl}}{M_{xx}^2}$$

$$\Sigma = \frac{H dx}{\sqrt{E M_{xx}}}$$



$$\sum_H = \left(\frac{H}{\sqrt{EM_x^2}} \right) \frac{H}{\sqrt{EM_x^2}} \sim \frac{H^2}{EM_x^2}$$

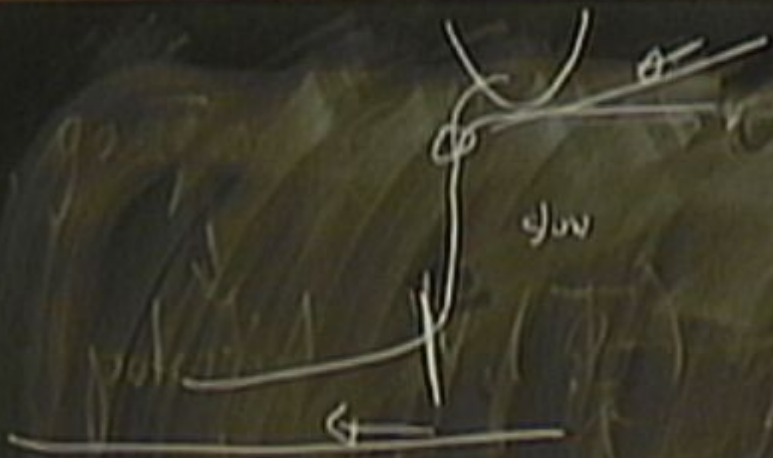
$$\sum_0 = \frac{H}{\sqrt{EM_{pl}}} M_{x^*}$$

$$T = M_p^2 \frac{2}{EM_x^2} < H^2 M_{pl}^2$$

$$\sum = \frac{H}{\sqrt{EM_{pl}}}$$

$$\sum_x < \frac{H M_{pl}}{\sqrt{EM_x^2}}$$

$$\frac{\delta P}{P} = \frac{H M_{pl}}{M_x^2}$$



$$\zeta_H = \left(\frac{H}{\sqrt{E} M_{pl}} \right) \frac{H}{\sqrt{E} M_{pl}} \sim \frac{H^2}{\sqrt{E} M_{pl}^2}$$

$$\zeta_0 = \frac{H}{\sqrt{E} M_{pl}} \quad M_{pl} = H e$$

$$T = M_{pl}^2 \frac{1}{\sqrt{E} M_{pl}^2} < H^2 M_{pl}^2$$

$$\zeta = \frac{\delta}{\sqrt{E} M_{pl}}$$

$$\zeta \downarrow < \frac{H M_{pl}}{\sqrt{E} M_{pl}^2}$$

$$\frac{\delta P}{P} = \frac{H M_{pl}}{M_{pl}^2} = \frac{M_{pl} e}{H} \sim 10 e$$

$$C_H = \left(\frac{H}{M_{*}} \right) \sqrt{\epsilon M_{*}} \quad \sqrt{\epsilon M_{*}^2}$$

$$\Sigma_0 = \frac{H}{\sqrt{\epsilon M_{pl}}} \quad M_{*} \sim 10^6 M_{\odot}$$

$$\frac{\delta P}{\phi} = \frac{H M_{pl}}{M_{*}^2} = \frac{M_{pl}}{H} e \quad \sim 10^6 e$$



←

$$T = M_p^2 \left(\frac{\delta \phi}{\sqrt{E} M_{pl}} \right)^2 < H^2 M_{pl}^2$$

$$\sum = \frac{\delta \phi}{\sqrt{E} M_{pl}}$$

$$\frac{\delta p}{p} \sim \beta_k$$

$$\sum \ll \frac{H \Lambda}{\sqrt{E} M_{pl}}$$

$$\sum \beta_k \ll H^2 M_{pl}^2$$

line

$$Z_4 = Z_4^* \begin{pmatrix} \# \\ \# \\ \# \\ \# \end{pmatrix} \wedge \begin{matrix} \#^2 \\ \#^2 \\ \#^2 \\ \#^2 \end{matrix}$$

Super H. 11.11.11

OUTLINE

$$\xi_H = \xi_* \left(\frac{H}{H_*} \right) \lesssim \frac{H_*^2}{\sqrt{\rho_*} H_*^2}$$

$$f_{NL} = \frac{\langle \xi^3 \rangle}{\langle \xi \rangle^3} =$$

Super-Hubble

10e

$$\zeta_H = \zeta_* \left(\frac{H}{H_*} \right) \sim \frac{H^2}{H_*^2}$$

$$f_{NL} = \frac{\langle \zeta^3 \rangle}{\langle \zeta^2 \rangle^2} = \frac{\frac{H^6}{\epsilon^{3/2} M_*^6}}{\frac{H^4}{\epsilon^2 M_*^4}} = \frac{H^2 M_*^4}{M_*^6}$$

$$M_{\text{star}} = H e^{N_{\text{H}}}$$

$$f_M \sim \frac{\sqrt{e} M_{\text{pl}}^4}{H^4 e^{6N_{\text{H}}}}$$

$$\sim 10^{-1} \times$$

< V_{inf}

βM_{pl}

$$M_{\downarrow} = H e^{N_{\downarrow}}$$

$$f_M \sim \frac{\sqrt{2} M_{\downarrow}^4}{H^4 e^{6N_{\downarrow}}}$$

$$\sim 10^{-1} \times 10^{24} \times e^{-6N_{\downarrow}}$$

$$\sim \frac{1}{10} e^{(53 - 6N_{\downarrow})}$$

$$N_{\downarrow} > 8.8$$

$$M_{\downarrow} = H e^{N_{\downarrow}}$$

$$f_M \sim \frac{\sqrt{e} M_{\downarrow}^4}{H^4 e^{6N_{\downarrow}}}$$

$$\sim 10^{-1} \times 10^{24} \times e^{-6N_{\downarrow}}$$

$$\sim \frac{1}{H} e^{(53 - 6N_{\downarrow})}$$

$$N_{\downarrow} > 8.8$$

$$55 + 8.8 \sim 64$$

$$\dot{\phi} \sim \epsilon M_{pl}^2 \dot{\chi}^2$$

$$+ H_I$$

$$\chi_H = \begin{pmatrix} H \\ \dots \end{pmatrix}$$

$$\chi$$

$$\delta\phi$$

$$\phi$$

$$\rho \sim \epsilon M_p^2 \dot{\zeta}^2$$

$$+ \frac{\dot{\phi}^4}{16 M_p^2} H^2 \dot{\zeta}^2 \frac{1}{\Delta^2}$$

$$\zeta_H = \left(\begin{array}{c} H \\ \vdots \end{array} \right)$$

$$\zeta$$

$$\delta \rho$$

$$\phi$$

$$\mathcal{L} \sim \epsilon M_p^2 \dot{\zeta}^2$$

$$+ \frac{\dot{\phi}^4}{16 M_p^2} H^2 \zeta^2 - \frac{\dot{\zeta}^2}{\Delta^2}$$

$$+ e^2 M_{pl}^2 H M_* \zeta^3$$

$$\vec{\zeta}_H = \begin{pmatrix} \zeta \\ \zeta \\ \zeta \end{pmatrix}$$

$$\vec{\zeta}$$

$$\frac{\delta \mathcal{L}}{\delta \phi}$$

$$\dot{\phi}^2 \sim \epsilon M_{pl}^2 \dot{\zeta}^2$$

$$+ \frac{\dot{\phi}^4}{16 M_{pl}^2} H \dot{\zeta}^2 \frac{1}{\Delta^2} \dot{\zeta}$$

$$+ e^2 M_{pl}^2 H M_* \dot{\zeta}^3$$

$$\dot{\zeta}_H = \left(\begin{array}{c} \dot{\zeta} \\ \dot{\zeta} \\ \dot{\zeta} \end{array} \right)$$

$$\dot{\zeta}$$

$$\delta \dot{\zeta}$$

$$\dot{\phi}$$

$$\begin{aligned}
 \mathcal{L} &\sim c M_p^2 \dot{\chi}^2 \\
 &+ \frac{\dot{\phi}^4}{16 M_p^2} H^2 \dot{\chi}^2 \frac{1}{\Delta^2} \\
 &+ e^2 M_{pl}^2 H M_* \dot{\chi}^3 < H^2 M_{pl}^2 \dot{\chi}^3 \\
 \mathcal{L}_H &= \left(\frac{H}{M_*} \right) \left(\frac{H}{M_*} \right) \\
 \mathcal{L}_0 &= \frac{H}{M_*} \\
 \frac{\delta \mathcal{L}}{\delta \phi} &=
 \end{aligned}$$

$$\rho \sim \epsilon M_p^2 \dot{\zeta}^2$$

$$+ \frac{\dot{\phi}^4}{H^4 M_p^2} H \dot{\zeta}^2 \frac{1}{\Delta^2} \dot{\zeta}$$

$$+ e^2 M_{pl}^2 H M_* \zeta_*^3 < H^2 M_{pl}^2 \zeta_0$$

$$\zeta_* = e^{-2/3} \left(\frac{H}{M_*} \right)^{1/3}$$

$$\frac{\delta P}{\phi} =$$

$$\zeta_H = \left(\frac{H}{M_*} \right)$$

$$\zeta_0 =$$

$$\begin{aligned}
 \rho &\sim \epsilon M_p^2 \dot{\zeta}^2 & \zeta_H &= \left(\frac{H}{M_*} \right) \dot{\zeta} \\
 &+ \frac{\dot{\phi}^4}{H^4 M_p^2} H \dot{\zeta}^2 \frac{1}{\Delta^2} \dot{\zeta} & & \\
 &+ e^2 M_{pl}^2 H M_* \zeta_*^3 < H^2 M_{pl}^2 & \zeta_* &= \\
 &\zeta_* = c^{-2/3} \left(\frac{H}{M_*} \right)^{1/3} & \frac{\delta P}{\phi} &= \\
 - f_{NL} &\sim \left(\frac{M_{pl}}{M_*} \right)^4
 \end{aligned}$$



$$\begin{aligned}
\dot{\phi} &\sim c M_{pl} \dot{\zeta}^2 & \zeta_H &= \\
+ \frac{\dot{\phi}^4}{16 M_{pl}^2} H \dot{\zeta}^2 & \frac{1}{\Delta^2} \dot{\zeta} \\
+ e^2 M_{pl}^2 H M_* \zeta_*^3 & < H^2 M_{pl}^2 \\
\langle a^\dagger a \rangle &= 0 & \zeta_* &= c^{-2/3} \left(\frac{H}{M_*} \right)^{1/3} \\
\langle a^\dagger a \rangle_{\neq} & & & \\
\langle a a a \rangle_{\neq 0} & f_{NL} \sim \left(\frac{M_{pl}}{M_*} \right)^4
\end{aligned}$$