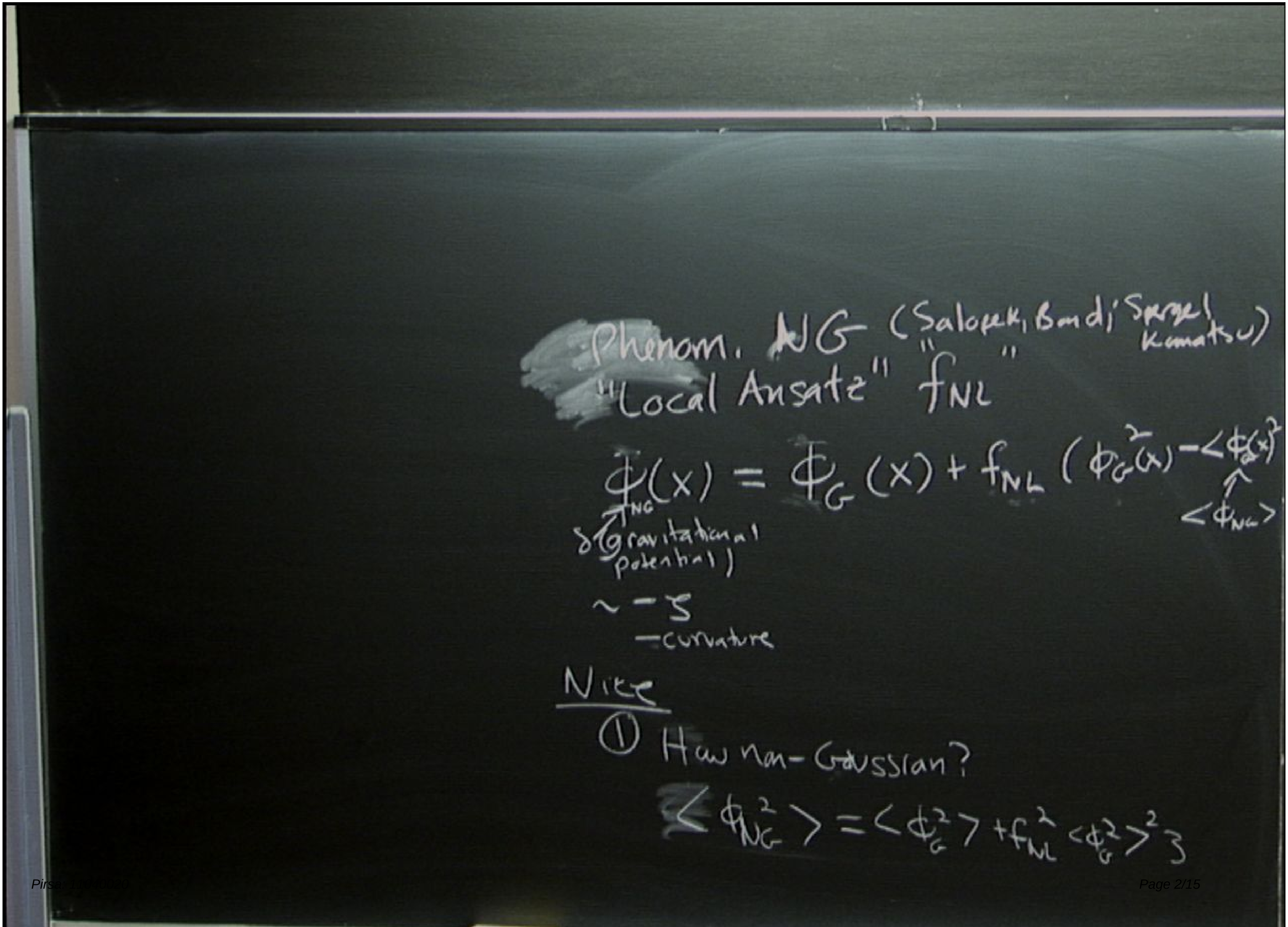
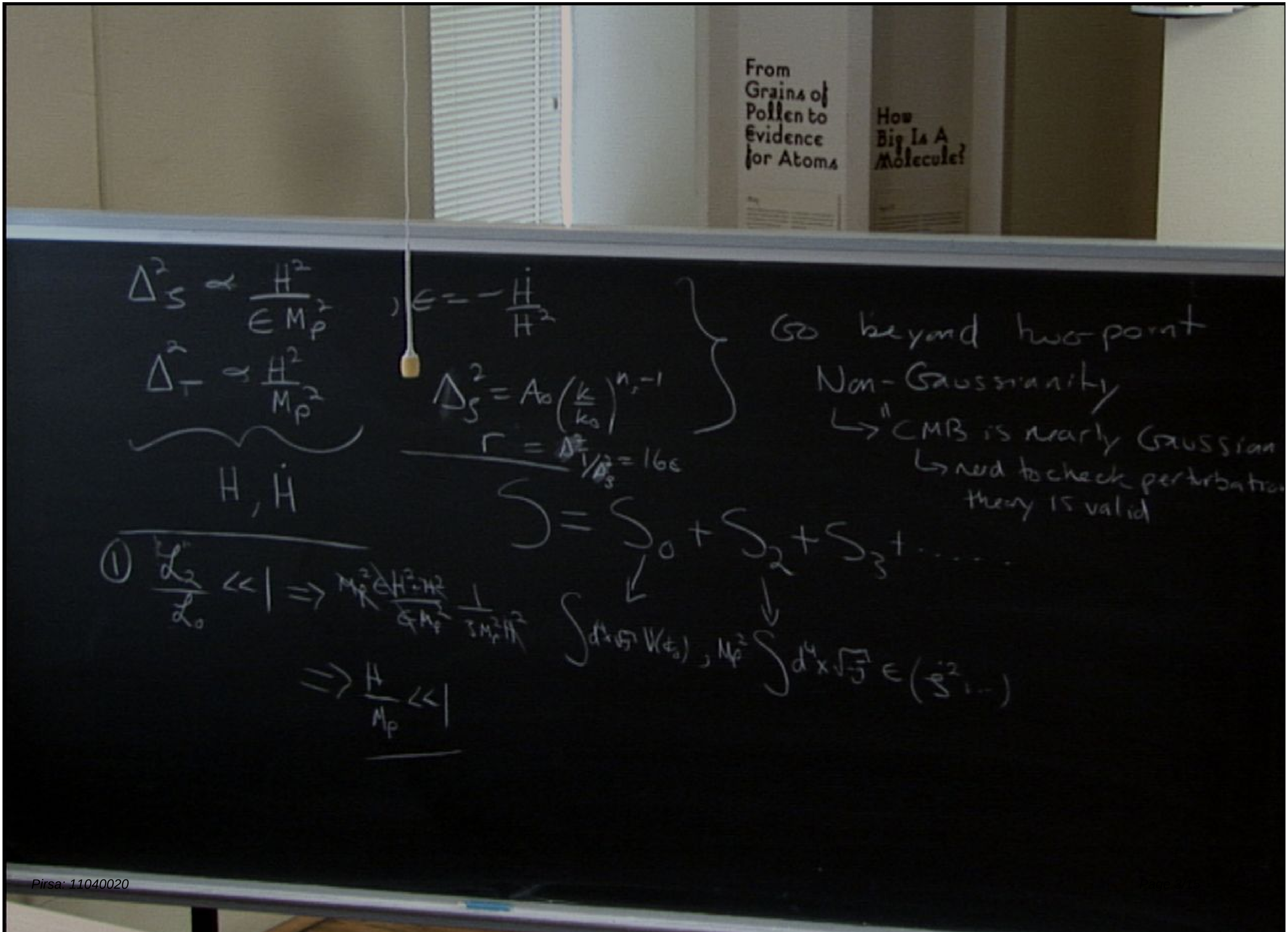
Title: Explorations in Cosmology - Lecture 14

Date: Apr 21, 2011 09:00 AM

URL: http://pirsa.org/11040020

Abstract:


Phenom. NG (Salopek, Bond; Spergel, Komatsu)
"Local Ansatz" "f_{NL}"
$\Phi_{NG}(x) = \Phi_G(x) + f_{NL}(\Phi_G^2(x) - \langle \Phi_G(x)^2 \rangle)$
$\langle \Phi_{NG} \rangle$
δ (gravitational potential)
$\sim -\zeta$
— curvature
Note
① How non-Gaussian?
$\langle \Phi_{NG}^2 \rangle = \langle \Phi_G^2 \rangle + f_{NL}^2 \langle \Phi_G^2 \rangle^2 3$


From Grains of Pollen to Evidence for Atoms
How Big Is A Molecule?
Go beyond two-point
Non-Gaussianity
"CMB is nearly Gaussian"
need to check perturbation theory is valid
H, Ḣ

>)

= 0

nearly Gaussian $\Rightarrow f_{NL}^2 \langle \phi_G^2 \rangle^2 \ll \langle \phi_G^2 \rangle$

$$f_{NL} \langle \phi_G^2 \rangle \ll 1$$

CMB: $f_{NL} \ll \frac{1}{\Delta_\zeta^2} \sim 10^{9/2}$

$$\boxed{f_{NL} \ll 10^5}$$

currently, CMB $|f_{NL}| \lesssim 60$

$\omega)$

$\phi_G(x)^2\rangle)$

$\langle\phi_{NL}\rangle = 0$

nearly Gaussian $\Rightarrow f_{NL}^2 \langle \phi_G^2 \rangle^2 \ll \langle \phi_G^2 \rangle$

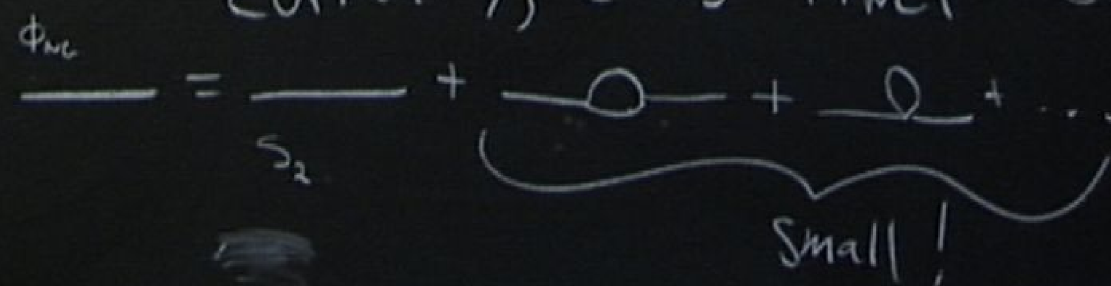
$f_{NL} \langle \phi_G^2 \rangle \ll 1$

CMB: $f_{NL} \ll \frac{1}{\Delta_\zeta^2} \sim 10^{9/2}$

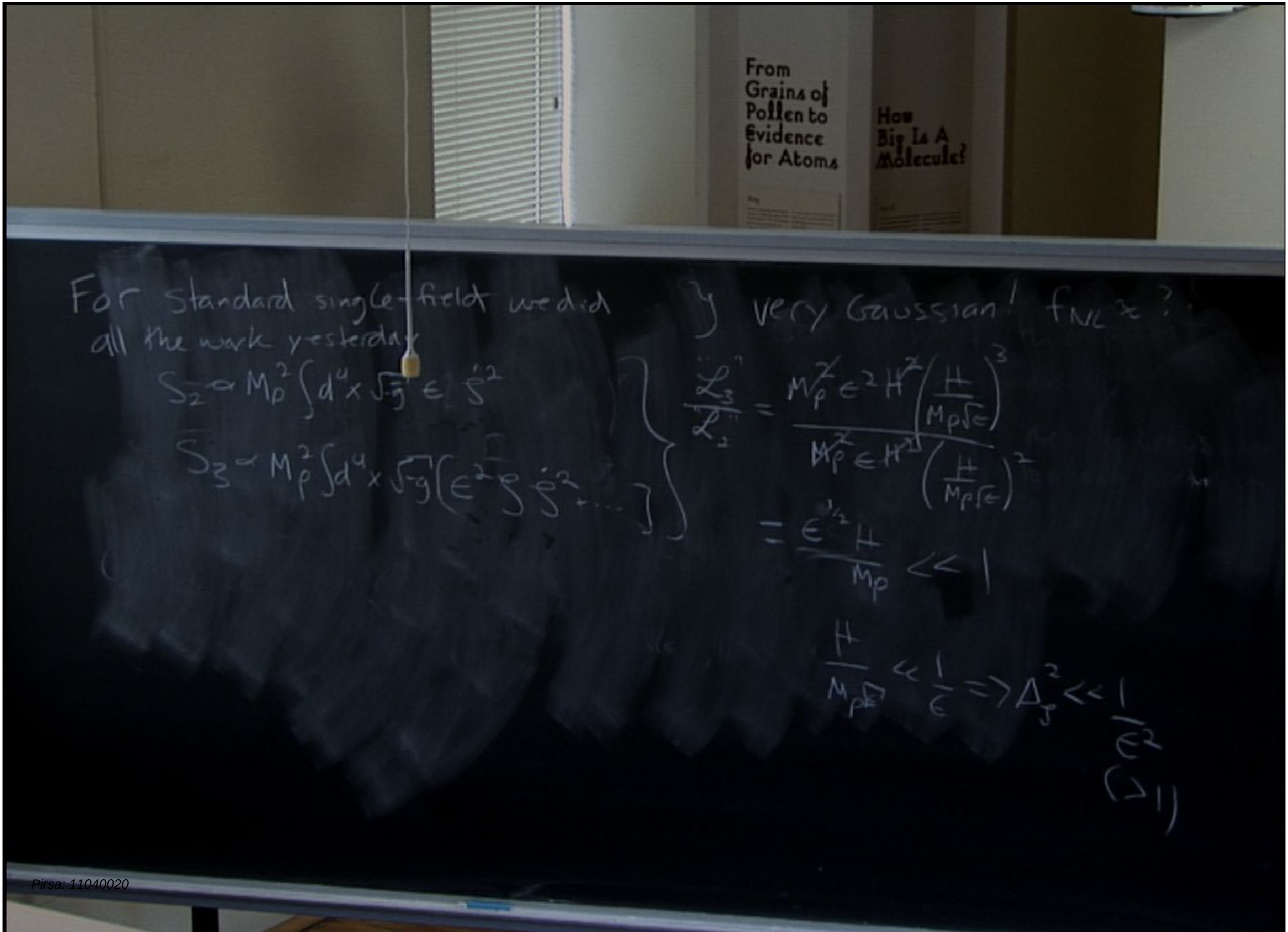
$\boxed{f_{NL} \ll 10^5}$

currently, CMB $|f_{NL}| \lesssim 60$

More formally:



$\Rightarrow \dfrac{``\mathcal{L}_3"}{``\mathcal{L}_2"}$

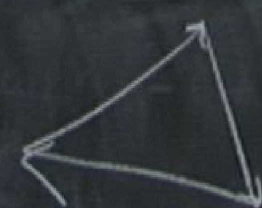

From Grains of Pollen to Evidence for Atoms
How Big Is A Molecule?
For standard single-field we did all the work yesterday
$S_2 \propto M_p^2 \int d^4x \sqrt{-g}\, \epsilon\, \dot{\zeta}^2$
$S_3 \propto M_p^2 \int d^4x \sqrt{-g} [\epsilon^2 \zeta \dot{\zeta}^2 + \dots]$
very Gaussian! $f_{NL} \approx$?
$\frac{"\mathcal{L}_3"}{"\mathcal{L}_2"} = \frac{M_p^2 \epsilon^2 H^2 \left(\frac{H}{M_p\sqrt{\epsilon}}\right)^3}{M_p^2 \epsilon H^2 \left(\frac{H}{M_p\sqrt{\epsilon}}\right)^2}$
$= \frac{\epsilon^{1/2} H}{M_p} << 1$
$\frac{H}{M_p\sqrt{\epsilon}} << \frac{1}{\epsilon} \Rightarrow \Delta_\zeta^2 << \frac{1}{\epsilon^2}$ (>1)

"Bispectrum"

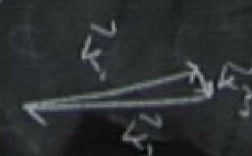
$$\langle \zeta_{\vec k_1} \zeta_{\vec k_2} \zeta_{\vec k_3} \rangle = (2\pi)^3 \delta^3(\vec k_1 + \vec k_2 + \vec k_3) * B(\vec k_1, \vec k_2, \vec k_3)$$

→ Local ansatz

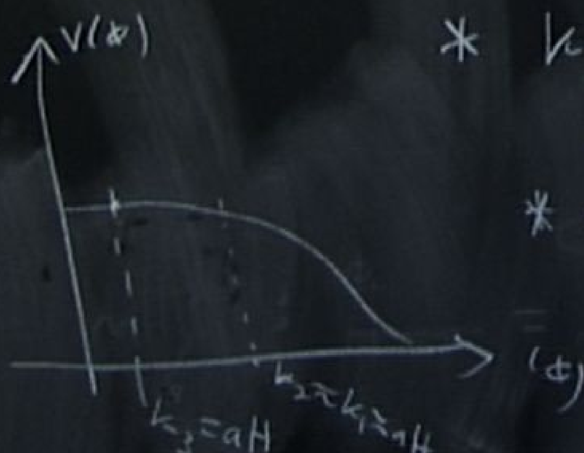
$$B(\vec k_1, \vec k_2, \vec k_3) = 2 f_{NL} \left(P(k_1) P(k_2) + \text{sym} \right)$$



, largest "squeezed limit"

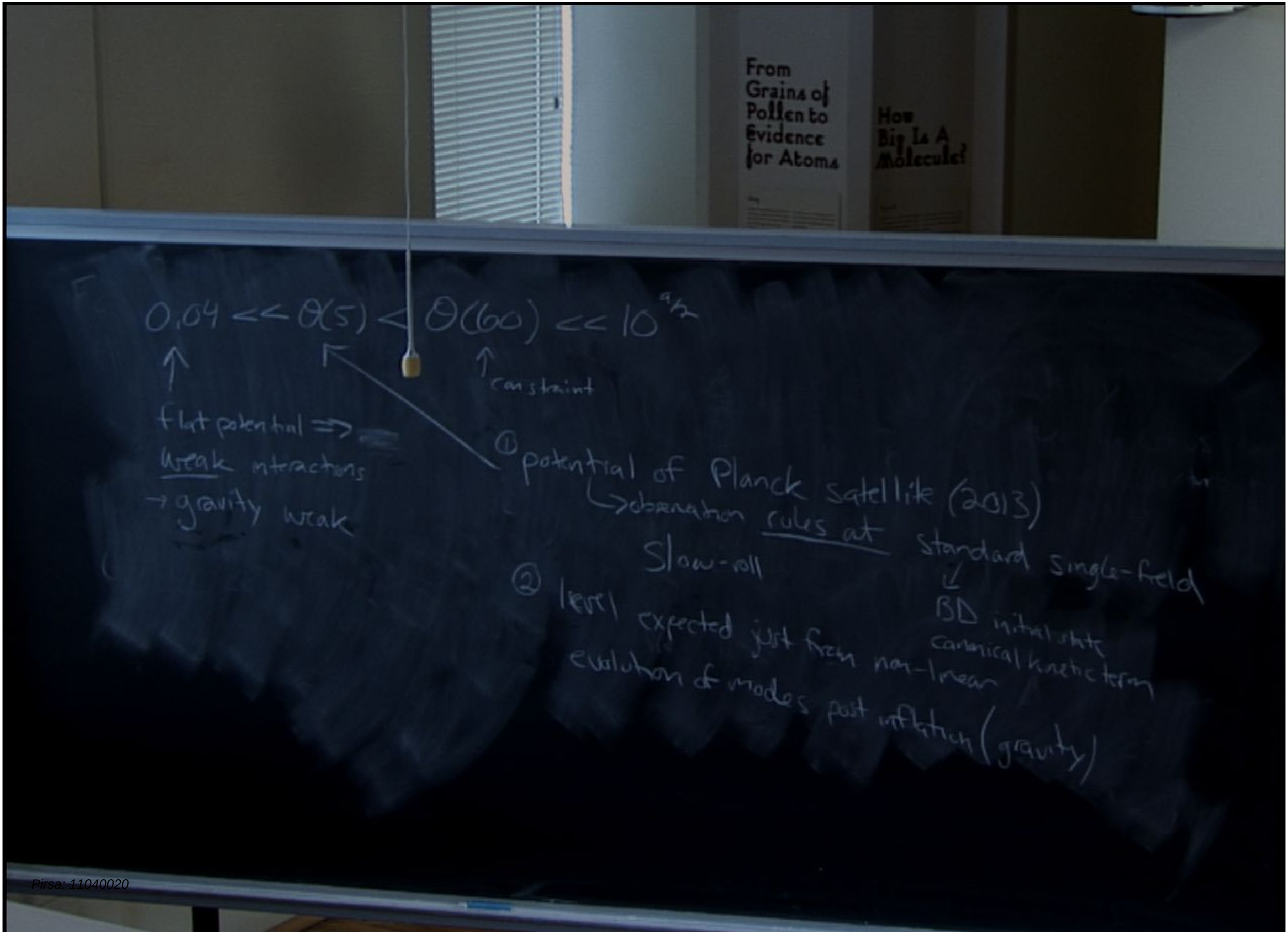


In slow roll, how big is correlation between $\vec{k}_3$ (long wavelength) and $\vec{k}_1 \approx \vec{k}_2$ (short wavelength)?



* k_3 fluctuation shifts "clock" for $\langle \zeta_{k_1} \zeta_{k_1} \rangle$
* shift meaningless if potential exactly flat

$\Rightarrow$ "f_{NL}" $\propto (n_s - 1) \approx 0.04$

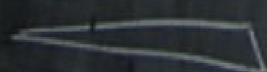

From Grains of Pollen to Evidence for Atoms
How Big Is A Molecule?
0.04 << O(5) < O(60) << 10^(9/2)
constraint
flat potential ⇒
weak interactions
→ gravity weak
① potential of Planck satellite (2013)
↳ observation rules out standard single-field slow-roll
BD initial state
canonical kinetic term
② level expected just from non-linear evolution of modes post inflation (gravity)

CMB constraints come from templates
for particular bispectra, with
"f_{NL}" from $B(k,k,k)/P^2(k)$

①  equilateral

Derivative interactions

$$g^{\mu\nu}\partial_\mu\phi\,\partial_\nu\phi + \frac{(g^{\mu\nu}\partial_\mu\phi\,\partial_\nu\phi)^2}{M^4} + \dots$$

②  squeezed, local, multiple fields

③  folded, Different deriv. interactions, Initial state

I Beyond CMB? Large Scale Structure

↳ unknown physics! (non-linear)

↳ Initial conditions, dark energy, dark matter, how to map observables back to IC's

↳ probe smaller scales (CMB sees nothing?)

Initial state

CMB constraints come from templates for particular bispectra, with "f_{NL}" from $B(k,k,k)/P^2(k)$

① equilateral

Derivative interactions

$$\frac{g^{\mu\nu}\partial_\mu\phi\,\partial_\nu\phi + (g^{\mu\nu}\partial_\mu\phi\,\partial_\nu\phi)^2}{M^4}$$

② squeezed, local, multiple fields

③ folded, Different deriv. interactions

Beyond CMB? Large Scale Structure

↳ unknown physics! (non-linear)

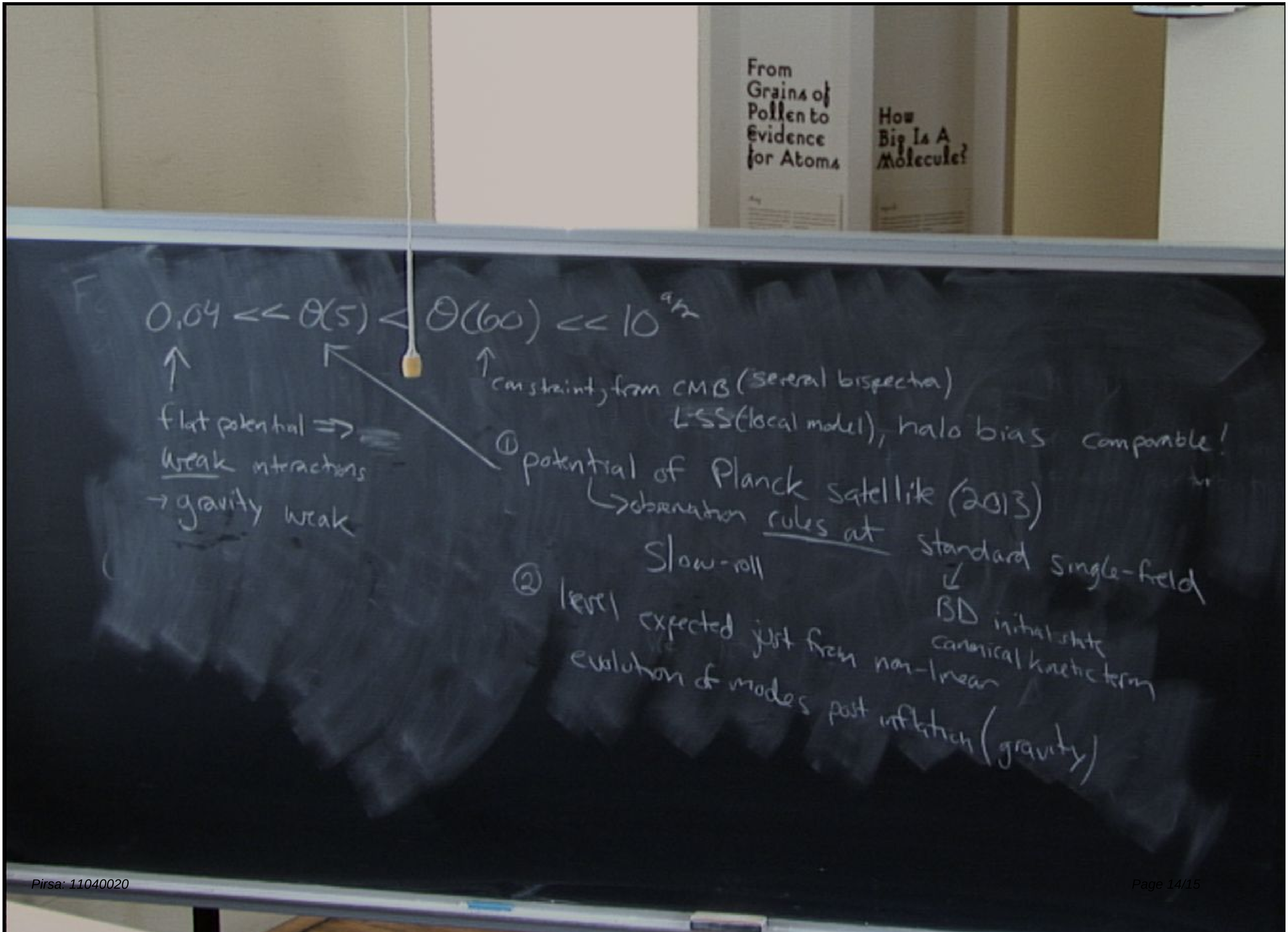
↳ Initial conditions, dark energy, dark matter, how to map observables back to IC's

↳ probe smaller scales (CMB sees nothing?)

↳ non-linear ⇒ NG can show up even in the power spectrum of, say, galaxies

$$P_{hh} = b^2(M, f_{NL}, k)\, P_{mm}$$

Initial state


From Grains of Pollen to Evidence for Atoms
How Big Is A Molecule?
0.04 << O(5) < O(60) << 10^{9/2}
constraint, from CMB (several bispectra)
LSS (local model), halo bias comparable!
flat potential ⇒
weak interactions
→ gravity weak
① potential of Planck satellite (2013)
↳ observation rules at
Slow-roll
standard single-field
BD initial state
canonical kinetic term
② level expected just from non-linear
evolution of modes post inflation (gravity)

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↳ non-linear & NG can show up even in the power spectrum of, say, galaxies

$$P_{hh} = b^2(M, f_{NL}, k)\, P_{mm}$$

↳ Lots of Data!

Initial state