Title: Primordial non-Gaussianity, statistics of collapsed objects, and the ISW effect

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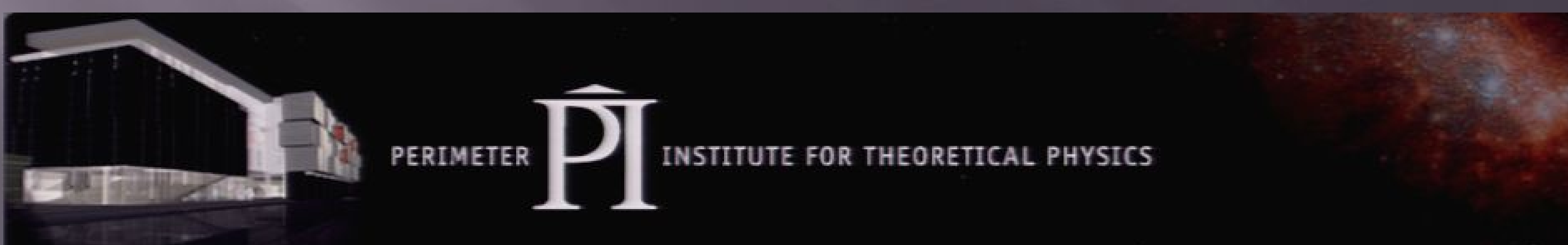
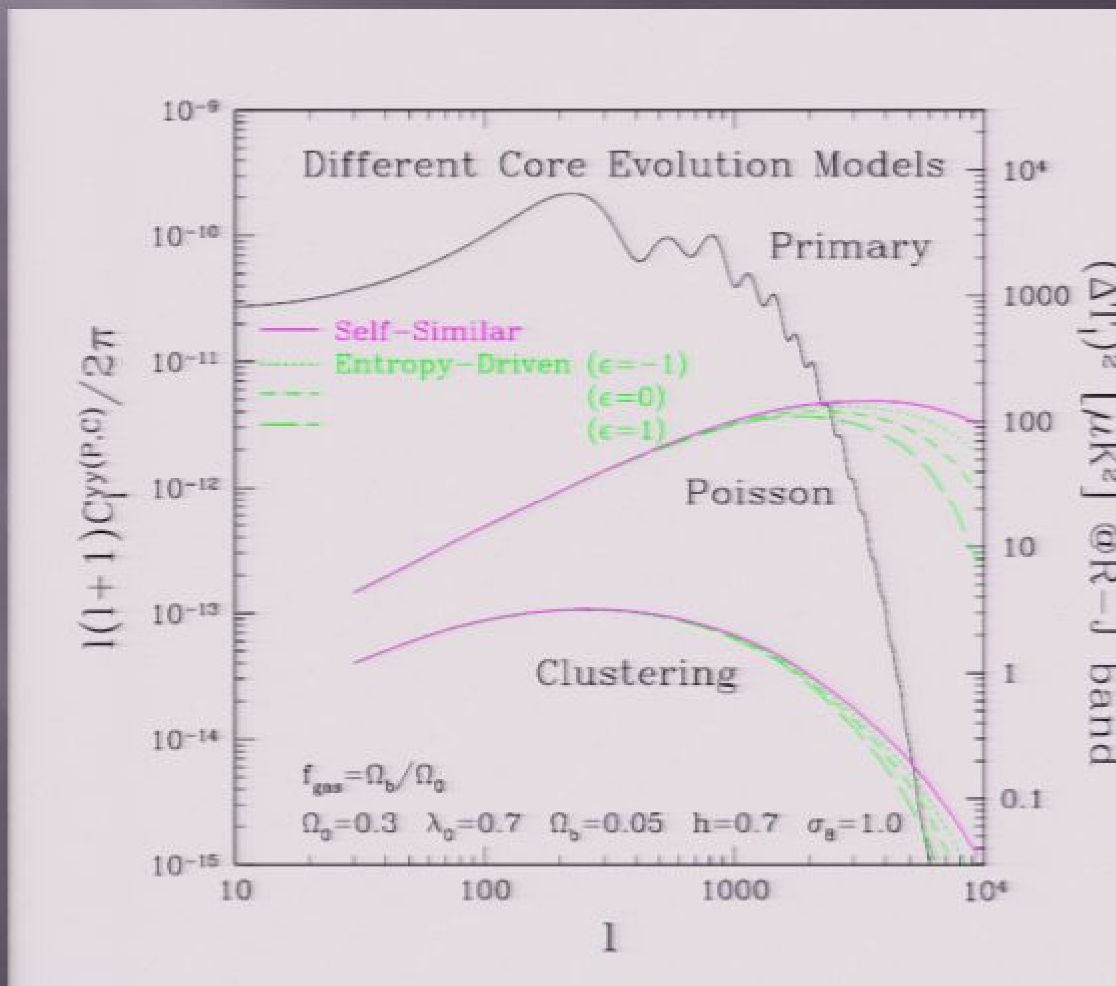
Abstract:

PRIMORDIAL NON-GAUSSIANITY, STATISTICS OF COLLAPSED OBJECTS , AND THE ISW EFFECT

Niayesh Afshordi



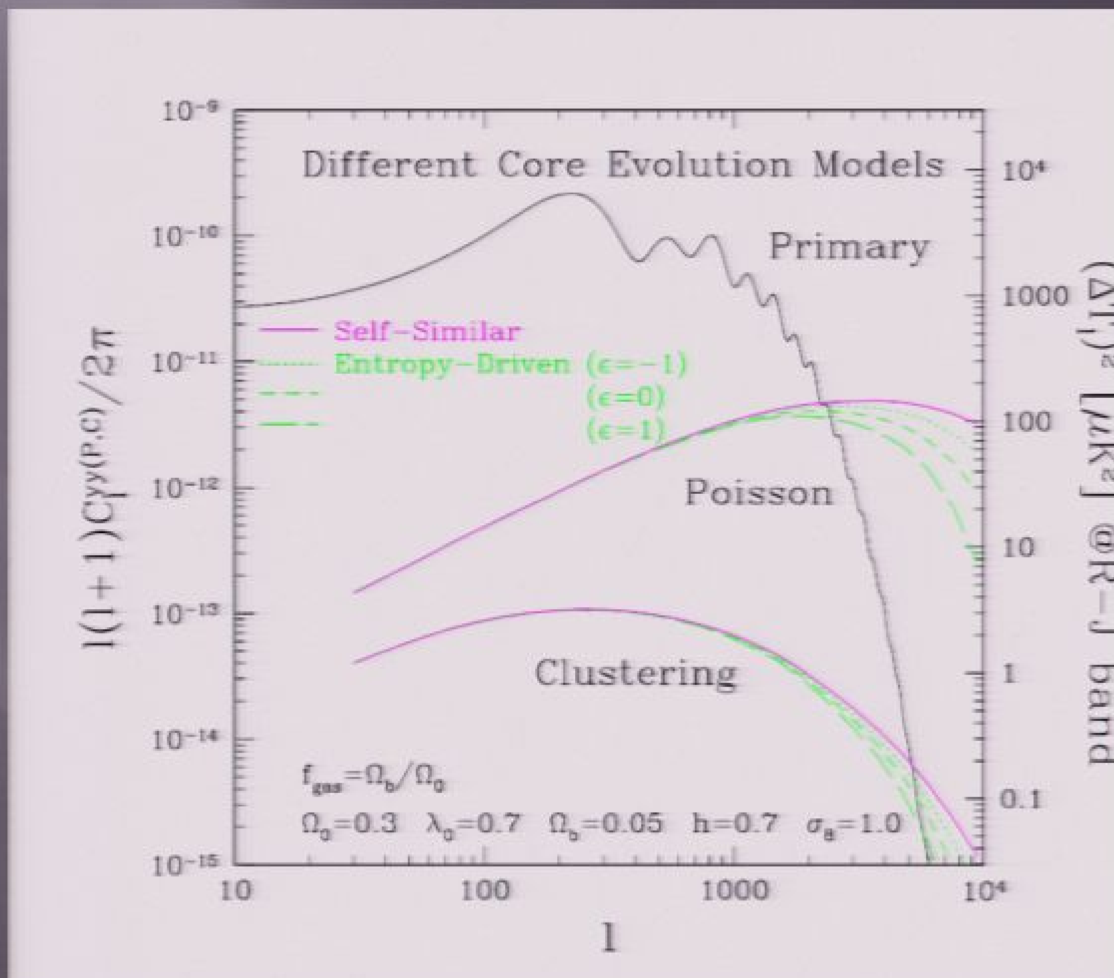
F_NL = 87!



Different Core Evolution Models
Primary
Self-Similar
Entropy-Driven (ε=−1)
(ε=0)
(ε=1)
Poisson
Clustering
$f_{gas}=\Omega_b/\Omega_0$
$\Omega_0=0.3$ $\lambda_0=0.7$ $\Omega_b=0.05$ $h=0.7$ $\sigma_8=1.0$
$l(l+1)C_l^{yy(P,C)}/2\pi$
$(\Delta T_l)^2$ [μK^2] @R−J band
l
10
100
1000
10^4
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
0.1
1
10
100
1000

F_NL = 87!

- SZ contamination: Komatsu & Kitayama 1999



Local primordial non-Gaussianity

$$\Phi(\mathbf{x})|_{\text{super}} = \Phi_{pG}(\mathbf{x}) - f_{NL}\left[\Phi_{pG}^2(\mathbf{x}) - \langle\Phi_{pG}^2(\mathbf{x})\rangle\right],$$

- Local approximation for density contrast:

$$\delta_m(\mathbf{x};t,M) \simeq \delta_{mG}(\mathbf{x};t,M) - f_{NL}\left\{2\Phi_{pG}(\mathbf{x};M)\delta_{mG}(\mathbf{x};t,M) + \frac{\epsilon(M)}{ag}\left[\delta_{mG}(\mathbf{x};t,M)\right]^2\right\},$$

$$\epsilon(M) \simeq \frac{a(t)A(k;t)}{T(k)} = \frac{2.0\times10^{-5}}{(\Omega_m h^2/0.128)\ln(1+2.34q)}\left[1+0.081q^{-1}+0.129q^{-2}+0.00192q^{-3}+0.00049q^{-4}\right]^{1/4}$$

$$q = \left(\frac{M}{8.1\times10^{13}M_\odot}\right)^{-1/3}.$$

Non-Gaussian collapse

$$\delta_m > \delta_{ec} \Rightarrow \delta_{mG} - 2 f_{NL} \delta_{ec} \Phi_{pG} \gtrsim \delta_{ec} + \frac{\epsilon f_{NL}}{ag} \delta_{ec}^2.$$

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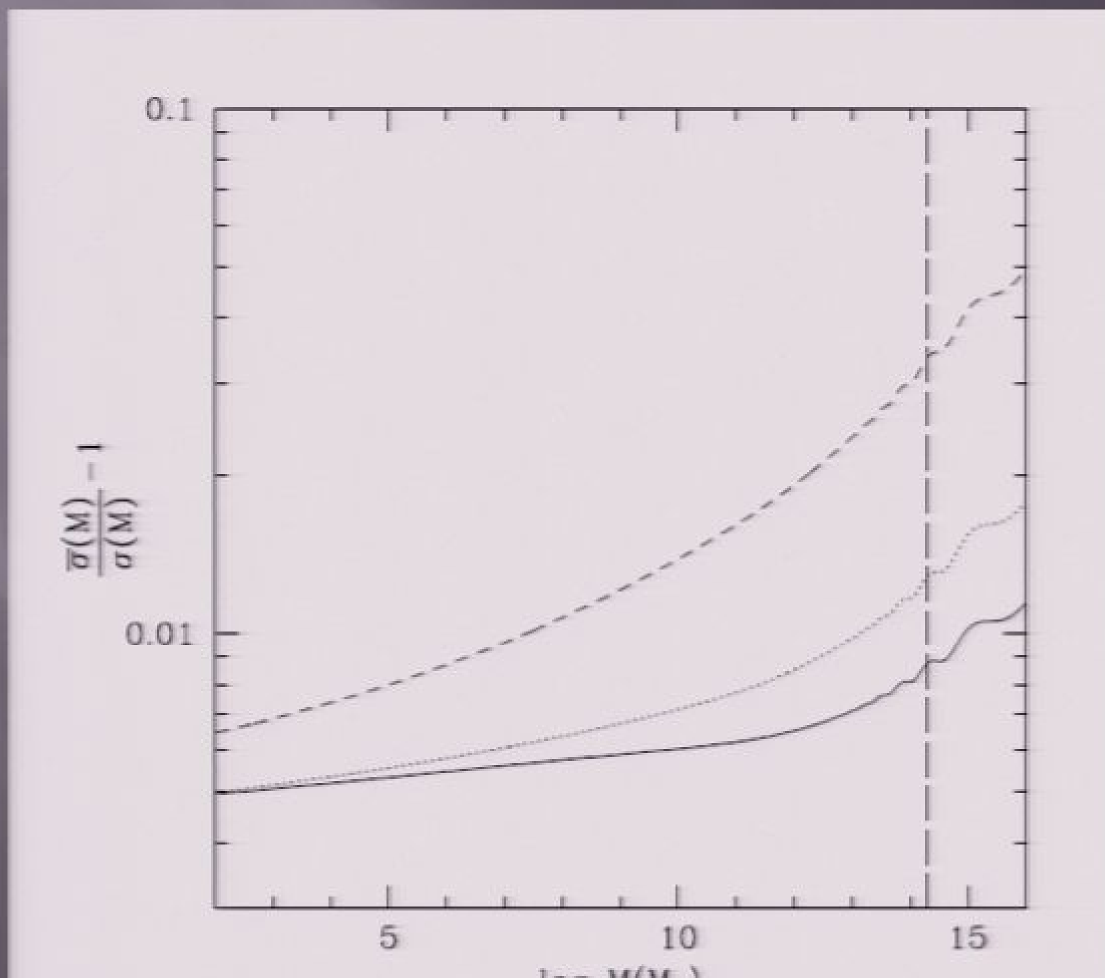

Clustering on large scales

$$\Phi = \Phi_G + f_{NL}\Phi_G^2$$

- This introduces mode-mode coupling

→ A large scale mode can modulate the statistics on small scales: $\Phi^s = \Phi^s_G\,(1+2f_{NL}\Phi_G{}^L)$

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Dalal et al. 2007

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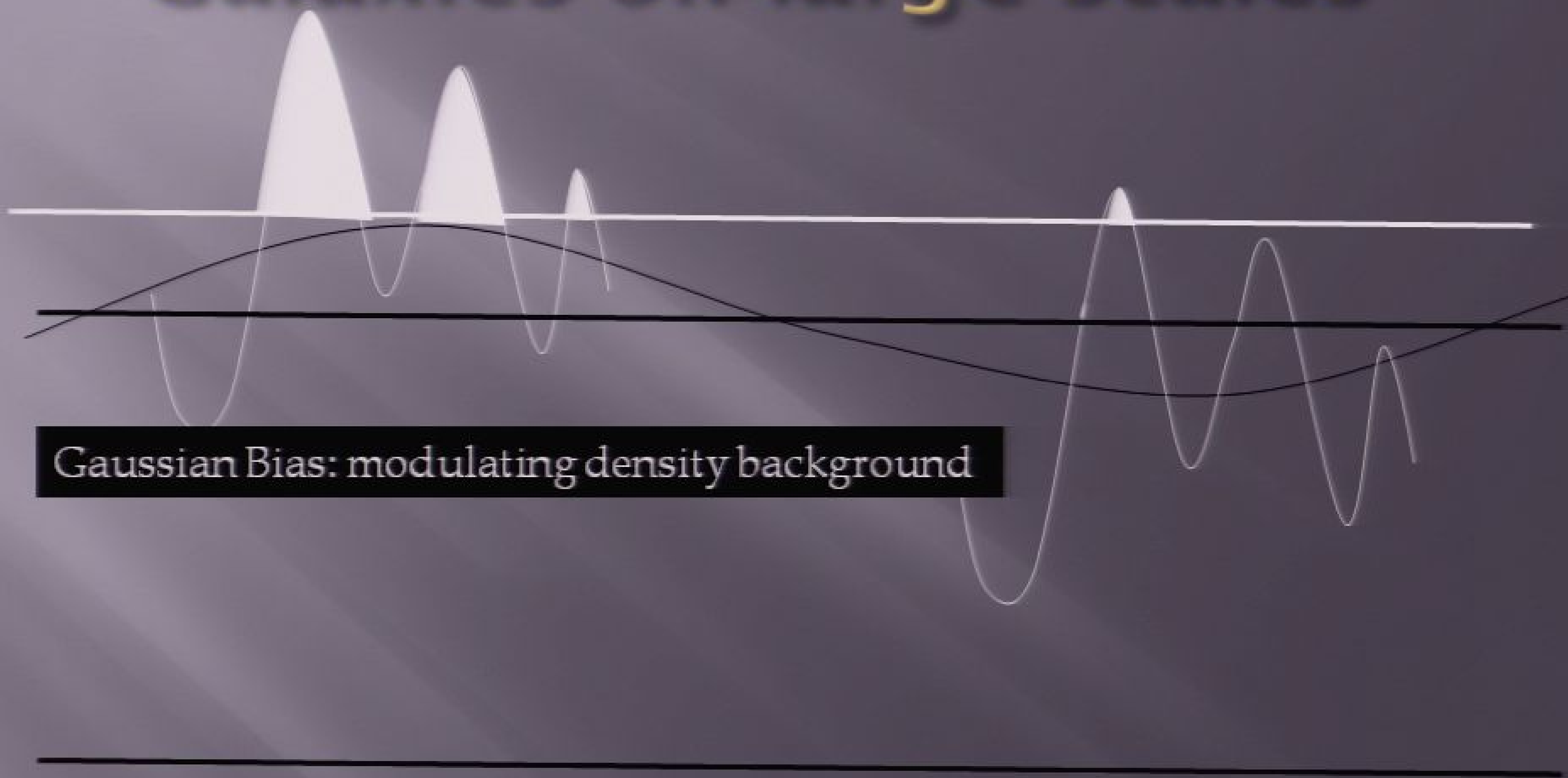
Galaxies on large scales



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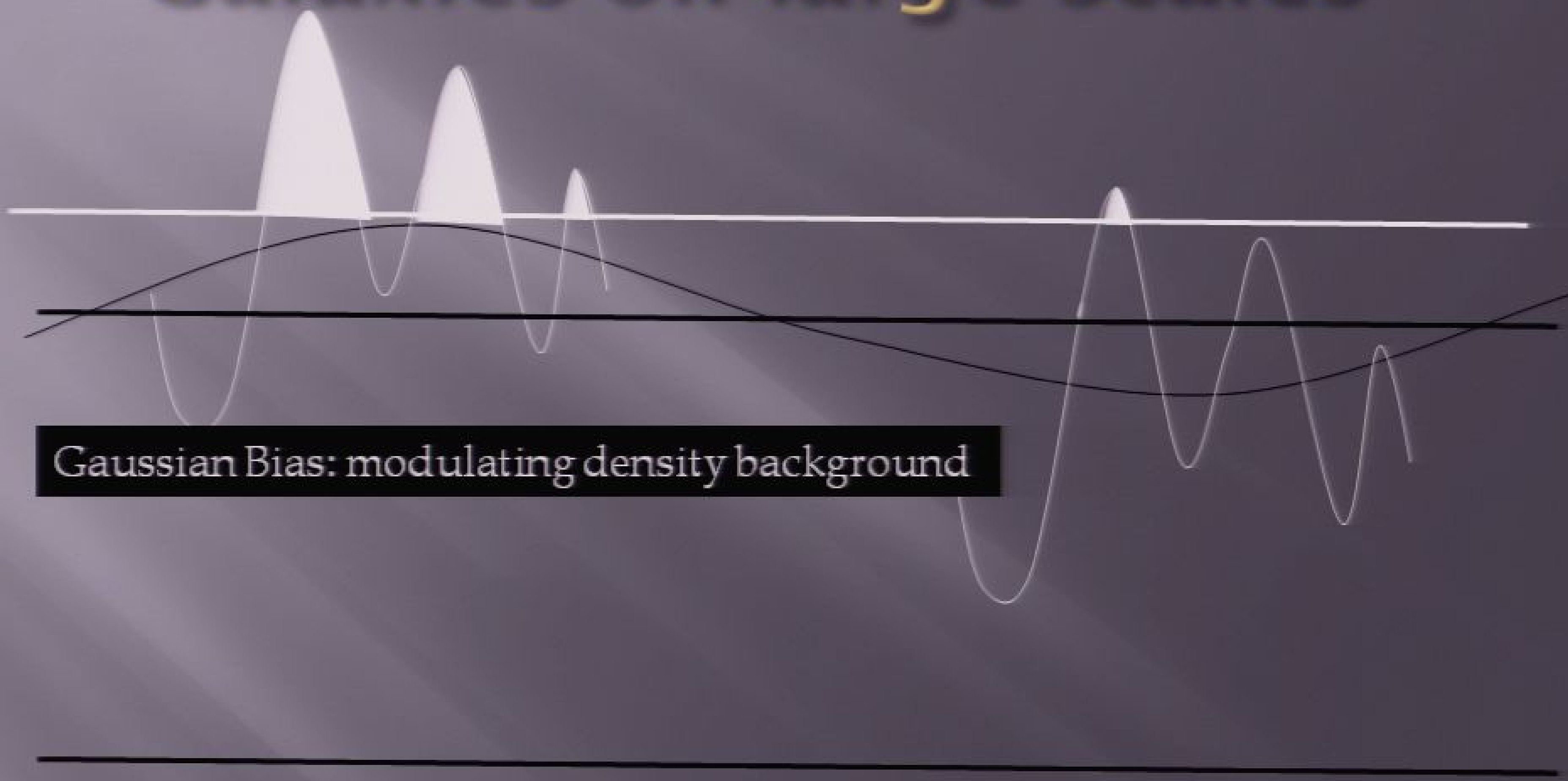

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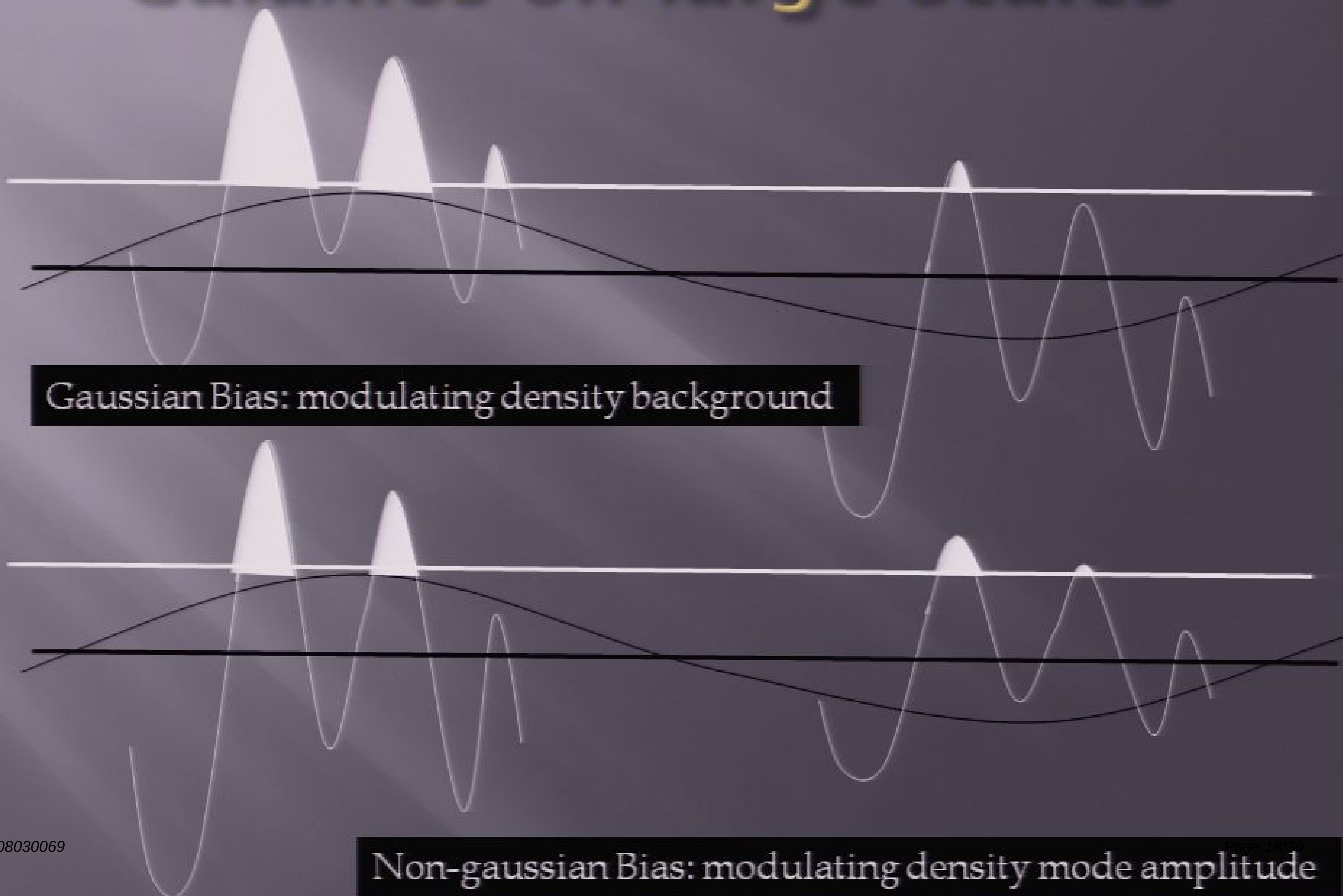
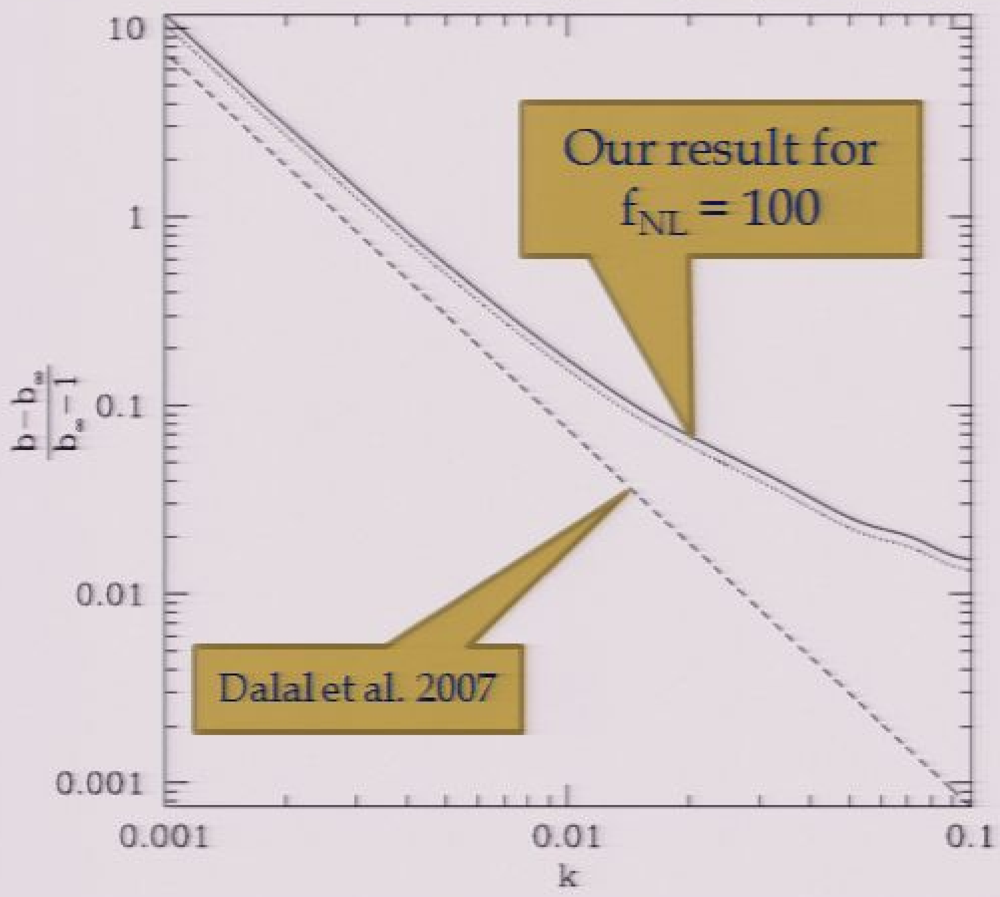


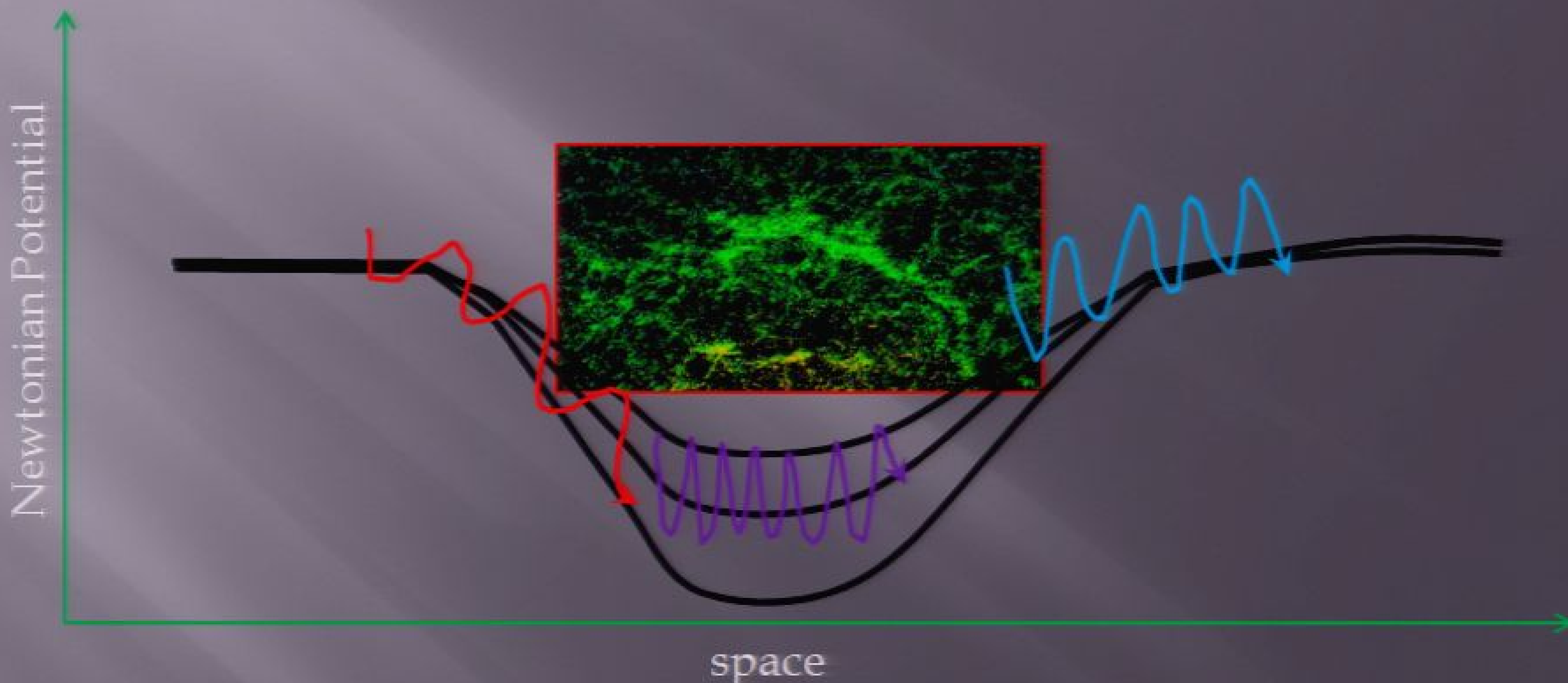
Scale-dependent galaxy bias

$$b(k, M) = b_\infty(M) + \frac{3(b_\infty - 1) f_{NL} \delta_{ec}(M) \Omega_m H_0^2}{k^2 a(t) g(t) T(k)},$$

NA & Tolley, in prep



Integrated Sachs-Wolfe (ISW) effect



- Accelerated Expansion results in decay of Newtonian potential
- ISW effect: decaying Newtonian potential causes secondary anisotropy in the CMB temperature:

$$\delta T = 2T \int \dot{\Phi} \, dt$$

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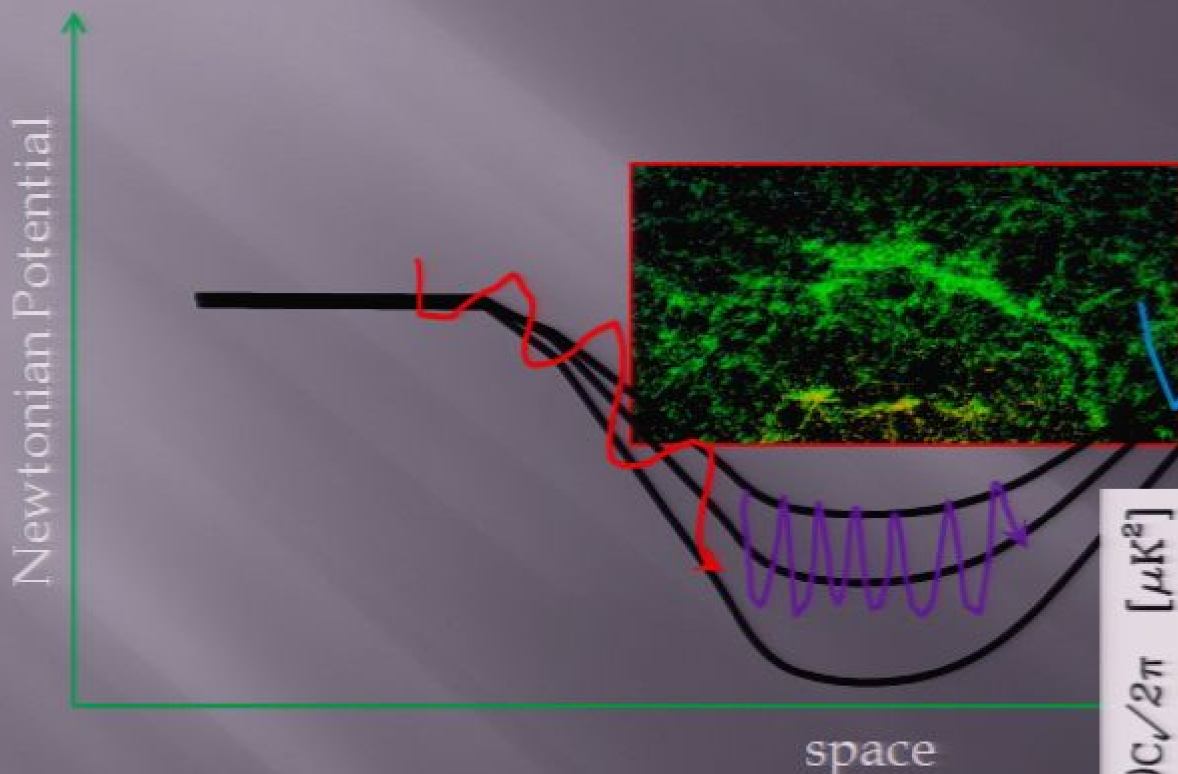
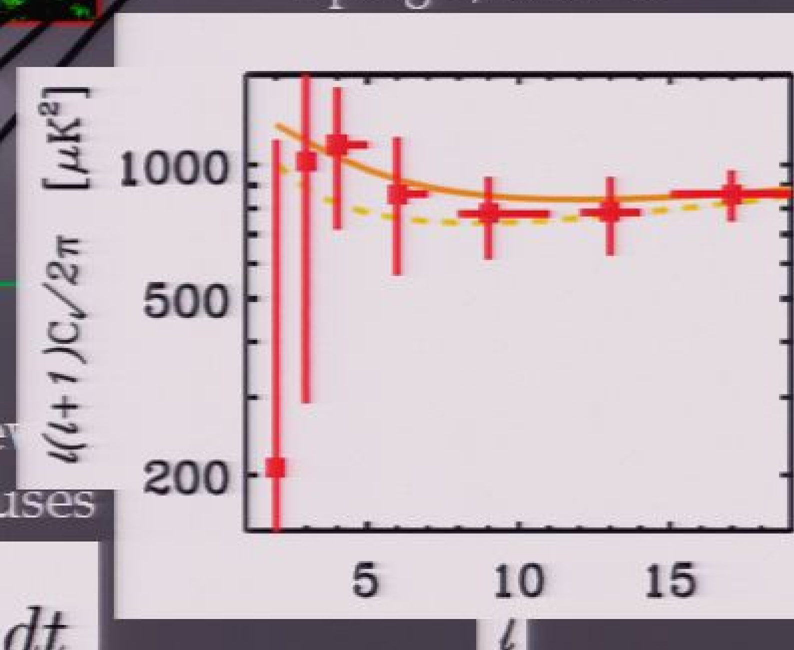


Spergel, et al. 06



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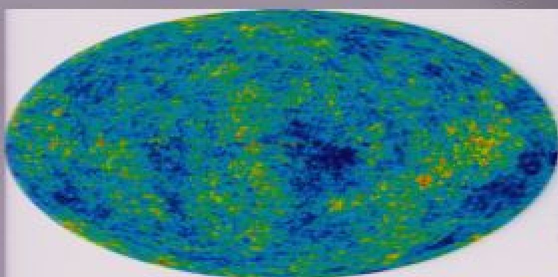
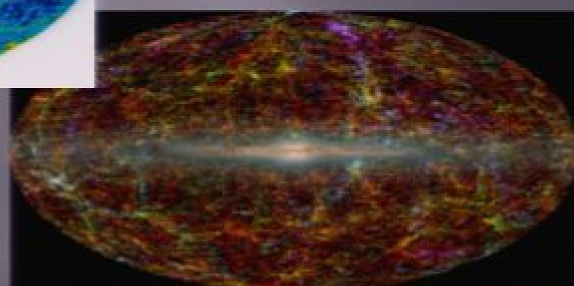
ISW in Cross-Correlation

Cosmic Microwave Background



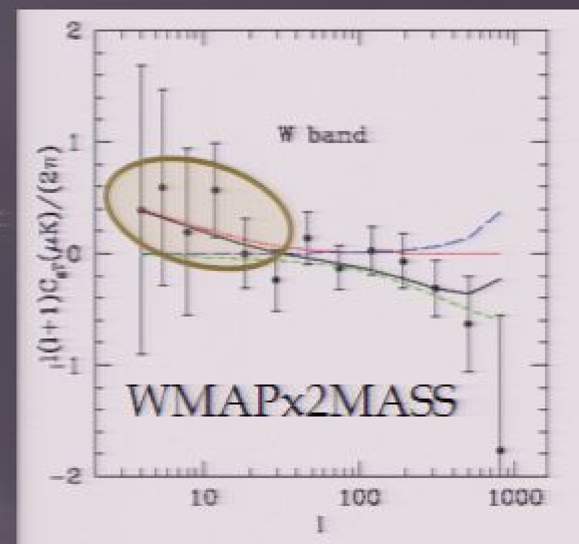
X



Galaxies

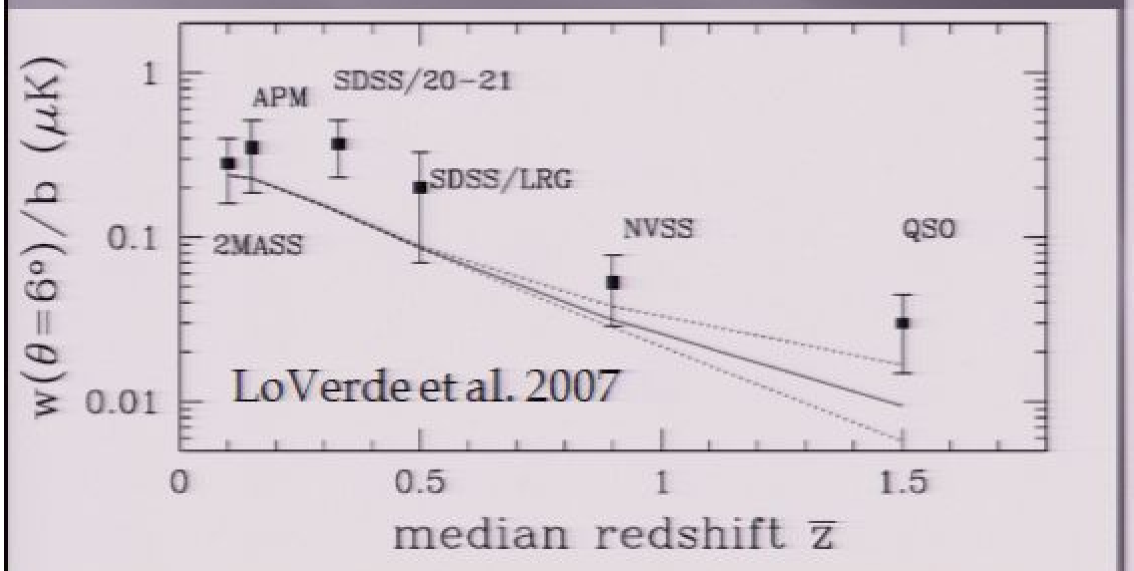
=

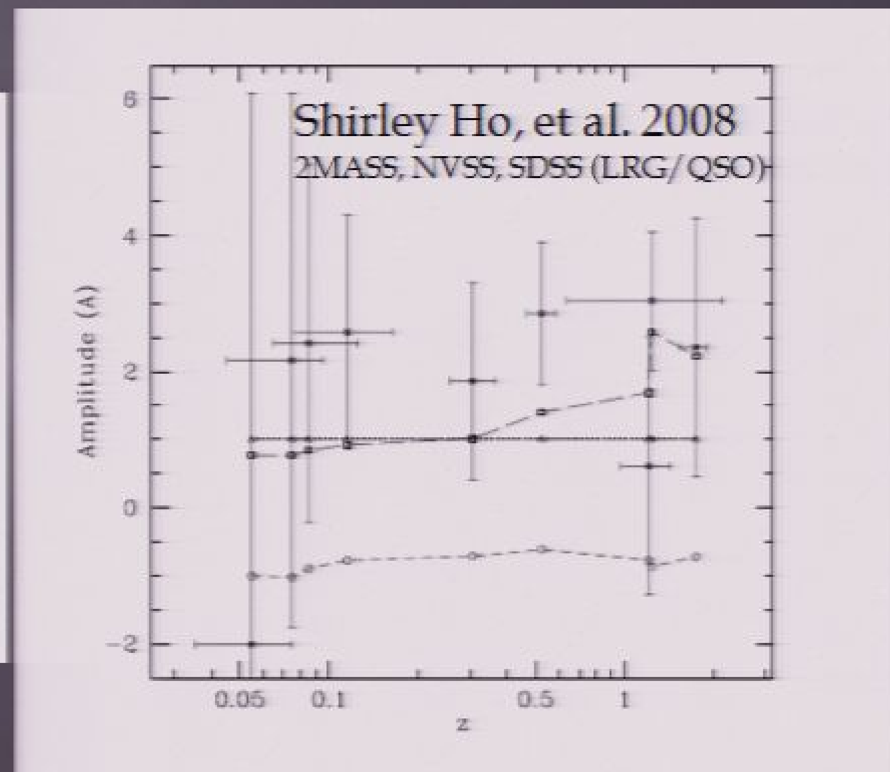
NA, Loh, & Strauss 2004



- Cross-correlating CMB with Galaxy distribution extracts the ISW signal from primary anisotropies
- Independent Evidence for Dark Energy

Do we see too much ISW?



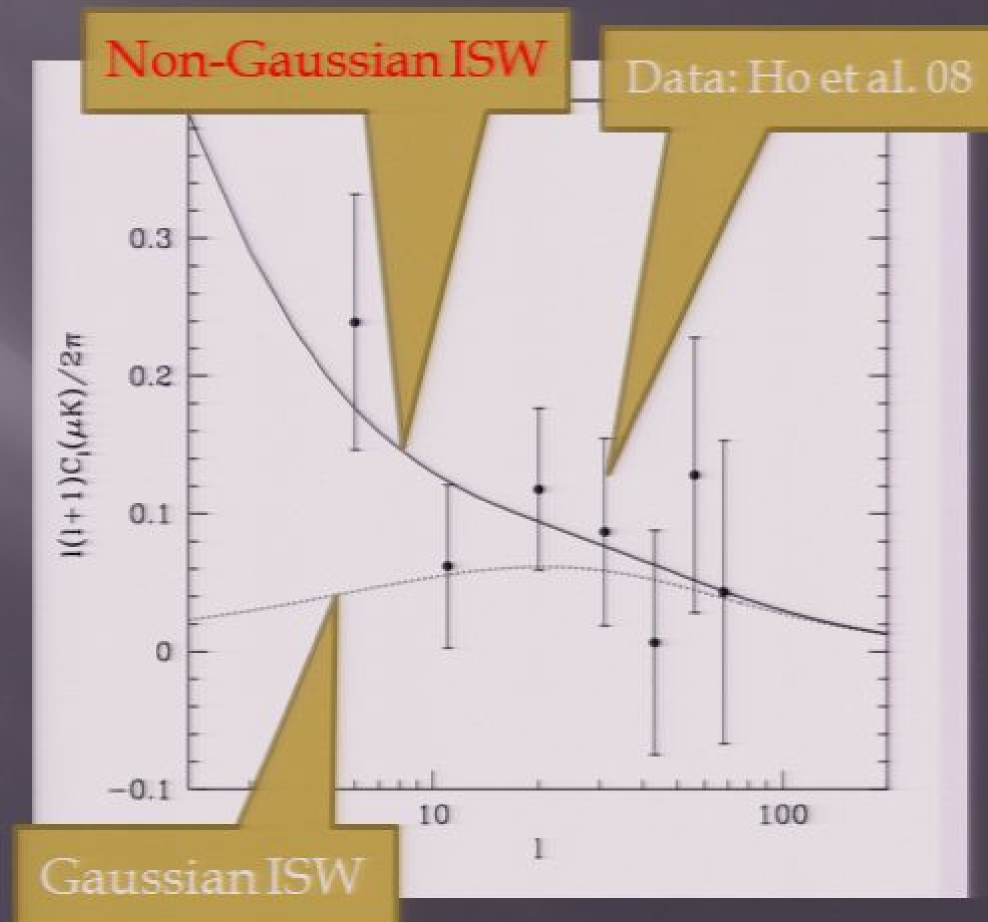


ISW: Observed / Expected = 2.23 ± 0.60

ISW and non-Gaussianity

- On large scales, galaxies follow the Newtonian potential (rather than DM density)
- So does ISW!
- This yields much bigger power on large scales
- $f_{NL} = 240 \pm 120$

NA & Tolley, in prep.



Cross-power spectrum NVSSxCMB
NA & Tolley, in prep.

Primordial non-Gaussianity, on the horizon

- $f_{NL} = 87 \pm 30$ (Yadav & Wandelt 07; WMAP3, l_{max}=750)
- $\Delta f_{NL} \sim 5$ (Planck satellite, in 3-5 years)

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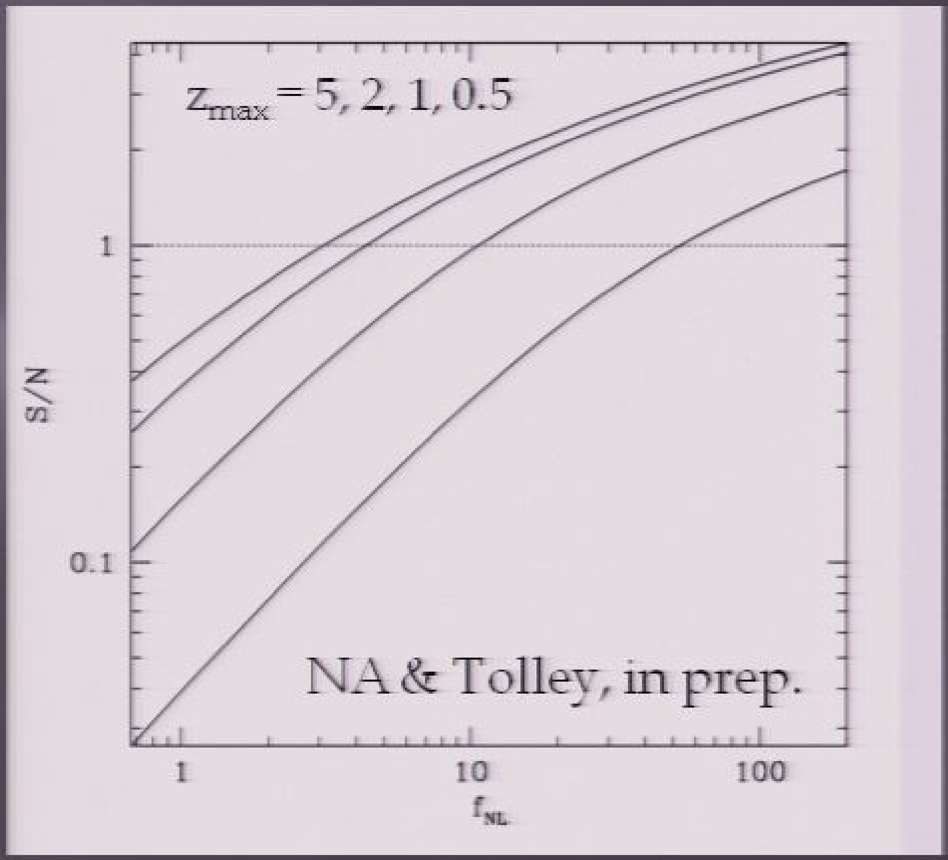
→insensitive to systematics



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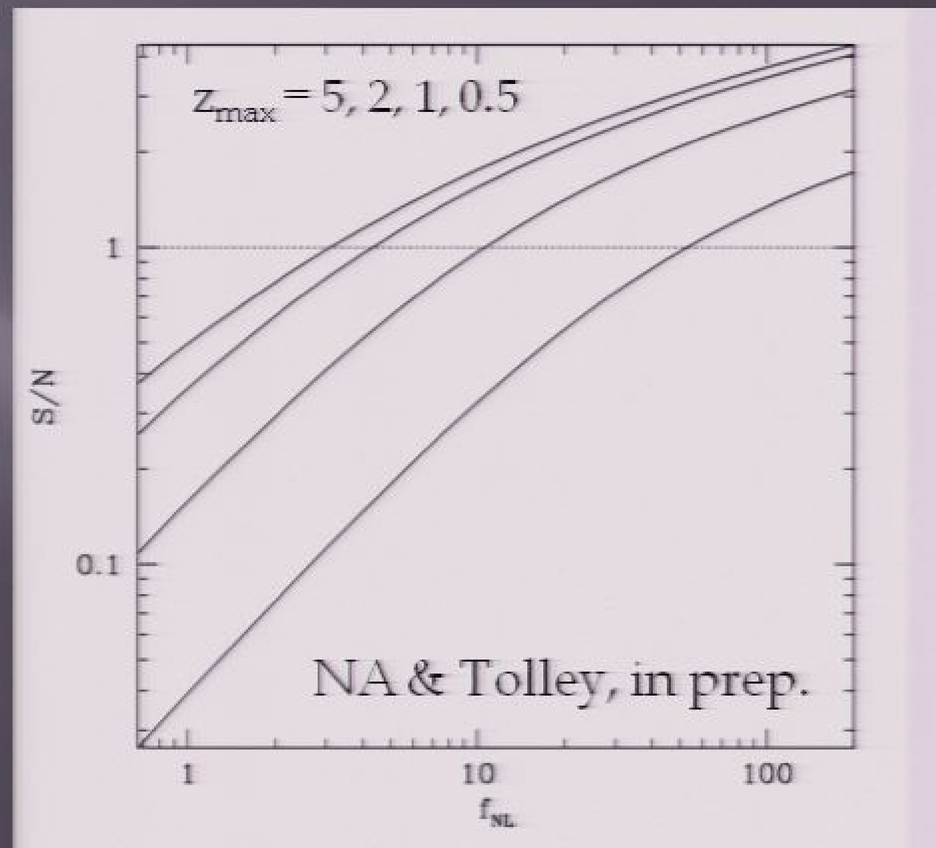

Conclusions

- General framework to model halo statistics with local primordial non-gaussianity
- From galaxy-CMB correlation: $f_{NL} = 240 \pm 120$
  - combined with WMAP5: 71 ± 29
- Galaxy*CMB, eventually gives: $\Delta f_{NL} = 3$

modern cosmology in perspective

- 1960′s: Cosmic Microwave Background
- 1970′s: Dark Matter
- 1980′s: Inflation
- 1990′s: CMB anisotropy (COBE, etc.)
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- 2010′s: Primordial Non-Gaussianity ???

March 6-10, 2008

PERIMETER PI INSTITUTE FOR THEORETICAL PHYSICS

NOVEL THEORIES OF THE EARLY UNIVERSE

ORIGINS AND OBSERVATIONS OF PRIMORDIAL NON-GAUSSIANITY

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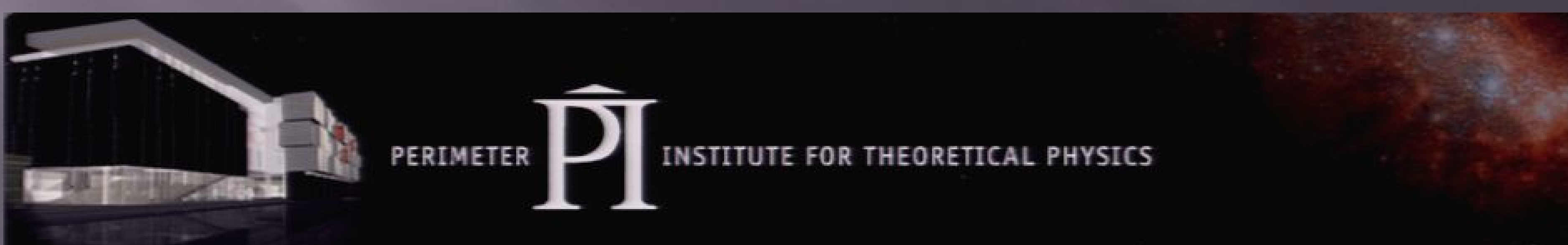

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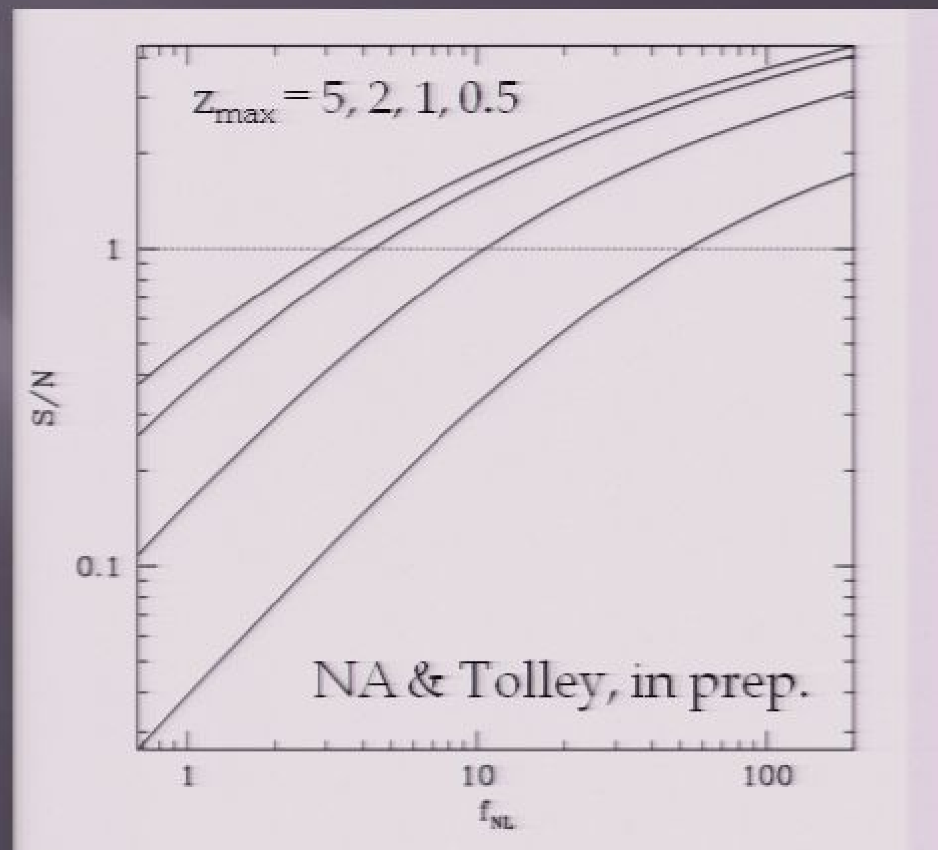

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