Magnification effect on galaxy-CMB lensing

~ Impact of magnification effect on estimating primordial non-Gaussianity from CMB and galaxy observation ~

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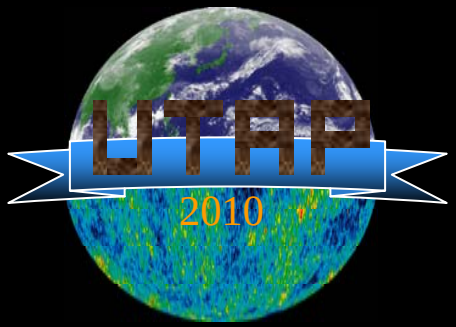

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Introduction

☆ Primordial non-Gaussianity

Any hint of primordial non-Gaussianity will be important to understand the mechanism of generating initial condition

Gaussian field

$$\Phi = \phi + f_{\rm NL}(\phi^2 - <\phi^2>)$$

local-type non-Gaussianity

The primordial curvature perturbation

☆ Tests of non-Gaussiniaty

(1) Bispectrum

$$B^{\rm loc}(k_1,k_2,k_3) = 2f_{\rm NL}[P_\phi(k_1)P_\phi(k_2) + ({\rm cyc})]$$

- Traditional method
- This technique would yield constraint on $f_{\rm NL}$ of $\sigma(f_{\rm NL}) \sim 3$ (Planck) (e.g. Serra & Cooray 08)

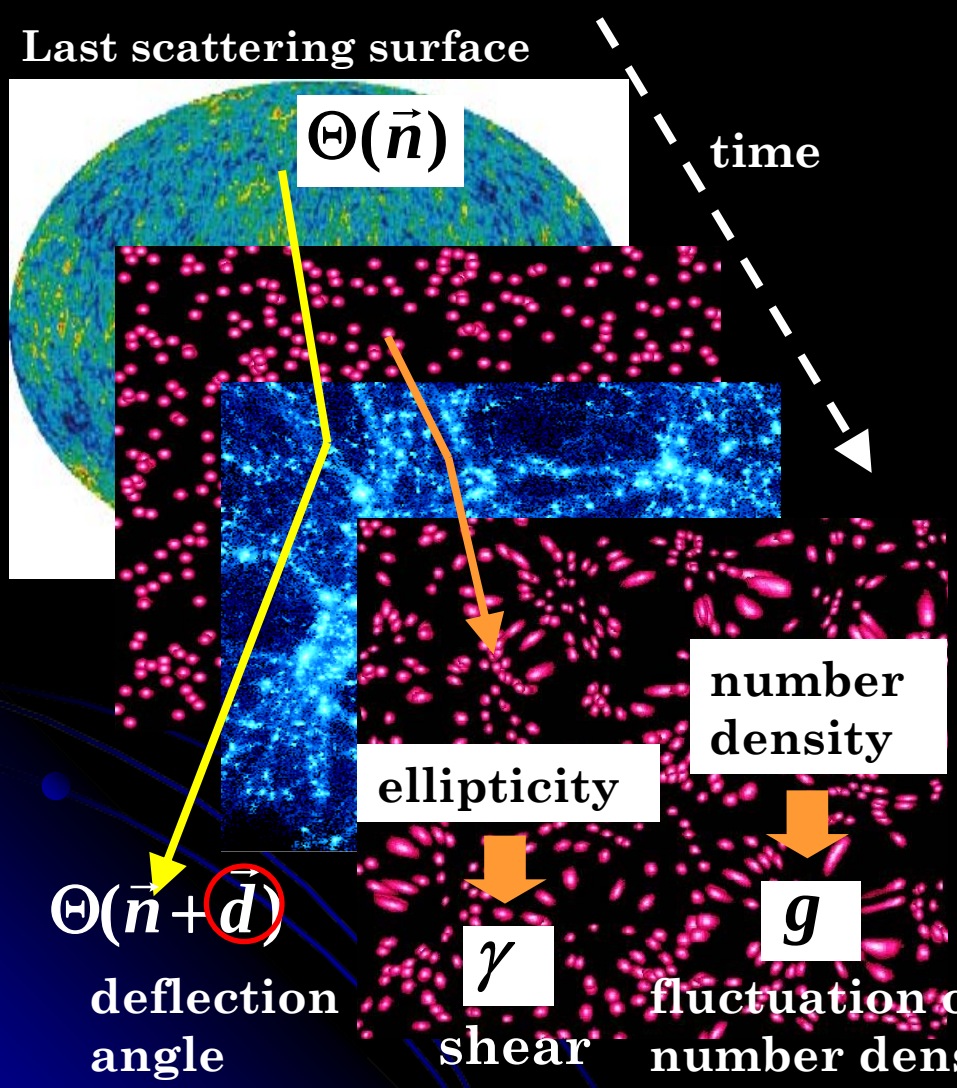
(2) Scale-dependent galaxy bias (e.g. Dalal+ 08)

$$b \to b + f_{NL} F(k,z)$$

- Presence of primordial non-Gaussianity cause scale-dependent galaxy bias
- This method can yield constraints of $\sigma(f_{\rm NL}) \sim$ a few (e.g. Carbone+ 08)

We explore sensitivity of imaging galaxy survey to the constraints on primordial non-Gaussianity

Observables in CMB & galaxy imaging survey



CMB		galaxy
Θ	temperature	g
E	E-polarization	γ
d	deflection angle	

power spectra

Information on f_{NL} is included in

$$gg \quad \gamma g \quad dg \quad \Theta g$$

These signals are not so sensitive to f_{NL} compared to gg, and usually neglected…

How well we can constrain f_{NL} by using all spectra ?

Magnification effect on galaxy number density

☆ However, *observed* galaxy number density is modified by weak lensing.

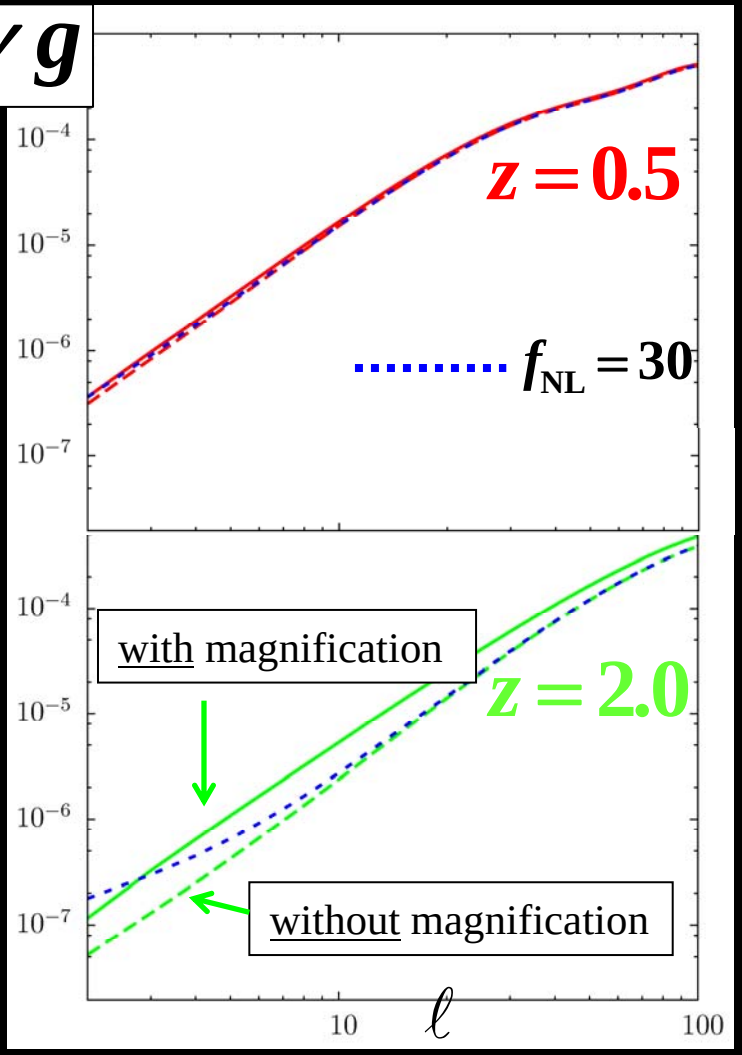
(Moessner +98, Matsubara 00)

(Magnification effect)

$$g \to g + (5s-2)\kappa$$

- g: fluctuation of galaxy density
- s: slope
- κ: convergence

$$\frac{\ell(\ell+1)}{2\pi} C_\ell$$



Power spectrum is modified by magnification at large scale and at high-z where the effect of non-Gaussianity become important.

Ignoring magnification in theoretical template would cause bias significantly on estimating f_{NL}

Our Work

We forecast

(1) constraints on f_{NL} through scale-dependent bias

(2) systematic bias due to ignoring magnification in theoretical template

by using all spectra obtained from CMB and galaxy survey

(we not include information from bispectrum)

・Other forecast studies to constrain f_{NL} through scale-dependent bias

e.g. Carbone+ 08, Afshordi & Tolley 08, Takeuchi+ 10

In our work,

・we consider all signals obtained from CMB and galaxy surveys

・we estimate impact of magnification on estimating f_{NL}

Details of calculation

[Cosmology]

flat ΛCDM, Gaussian initial condition

$\Omega_b h^2$	$\Omega_m h^2$	Ω_Λ	w	n_s	$A_s \times 10^9$	τ	f_{NL}
0.022	0.13	0.72	-1.0	0.96	2.4	0.086	0.0

[Survey]

CMB experiment : Planck

Galaxy survey: LSST-like → $f_{sky} = 0.5$, $z_m = 1.5$, $N_g = 100\ [/\,\mathrm{arc\,min}^2]$

[Model of galaxy samples]

- Redshift distribution

$$n(z) \propto z^2 \exp[-(z/0.96)^{1.5}]$$

with 3 redshift bins

- Bias model

$$b = b_0 + b_z / D(z)$$

$$\begin{cases} b_0 = 1.5 \\ b_z = 2.0 \end{cases}$$

- Intrinsic ellipticity

$$\gamma_{\mathrm{int}} = 0.3$$

Then, we calculate Fisher matrix and estimate

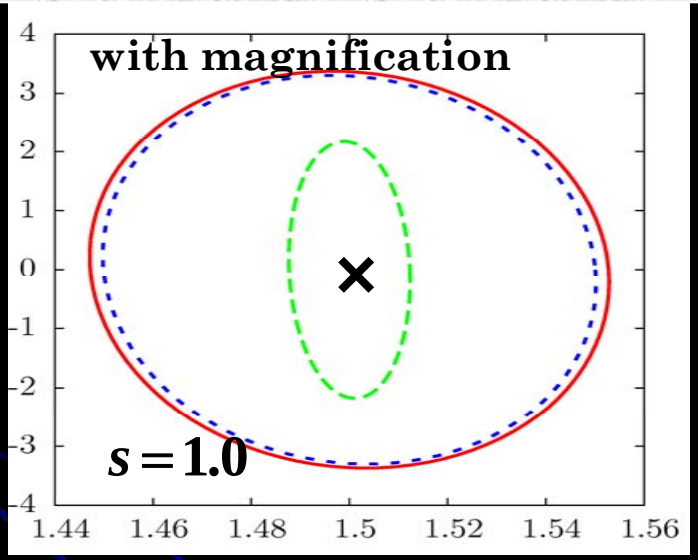
- 1-σ marginalized error on f_{NL}
- systematic bias due to ignoring magnification

by using auto/cross correlations of Θ E d γ g

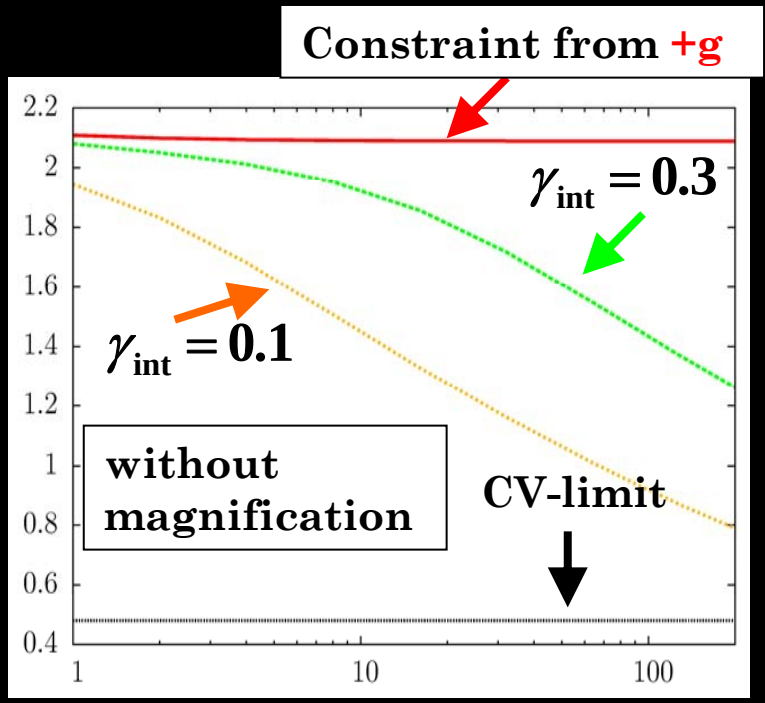
Result 1 (Constraints on f_{NL})

[1- σ contour]

CMB with
+g
+g+d
+g+d+γ



[sensitivity to Ng]



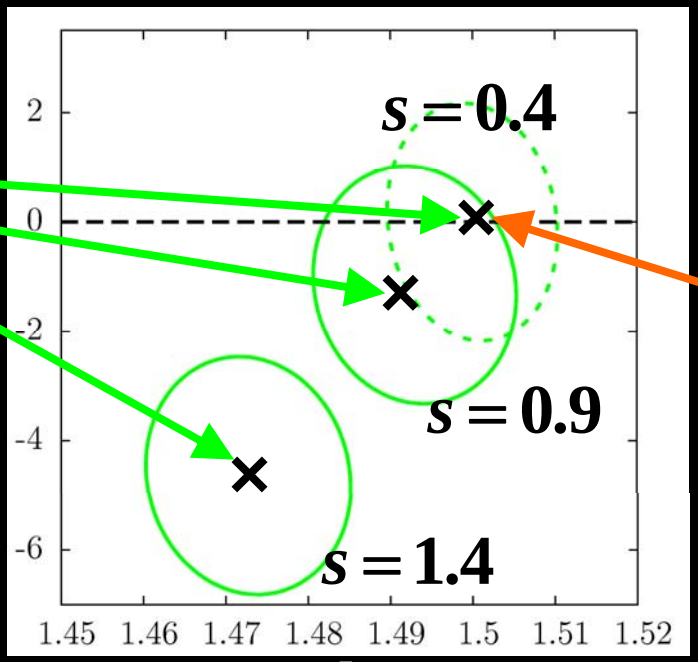
Including γ g, improvement of the constraint is by a factor of ~1.5-2

The constraint is sensitive to shear noise

Constraint on f_{NL} is improved by a factor of ~2 compared to galaxy count alone

Result 2 (effect of magnification)

[Systematic bias due to ignoring magnification]



Best fit value

fiducial value

Note: magnification vanishes if s=0.4

Although the constraint is insensitive to magnification, neglecting magnification effect in theoretical template cause significant bias on estimating f_{NL}

Summary

We explored

(1) how well we can constrain f_{NL} by using all spectra

(2) significance of systematic bias due to ignoring magnification

We found that

(1) if we use all signals, improvement of $\sigma(f_{NL})$ is by a factor of ~2 compared to galaxy count alone.

(2) Although the constraint is insensitive to magnification, ignoring magnification in theoretical template cause highly biased estimation on f_{NL}

If we take into account the effect of magnification, constraint on f_{NL} is further improved by using all information obtained from imaging survey of galaxy