Cosmology with Large Scale Structure Formation

Chaired by Jai-chan Hwang
Arranged by Chan-Gyung Park

Introduction

Y.S. Song

- Dark energy prospect: multiple probes strategy
  - H.J. Seo Re-capturing cosmic information with log mapping
  - J. Blazek Galaxy intrinsic alignment and gravitational lensing
  - J.Y. Yoo Supersonic relative velocity effect on BAO measurements
  - C.-G. Park What happens if dark energy perturbation is ignored?
- Is acceleration caused by modified gravity instead?
  - Y.S. Song Cosmological test of GR using both WL and coherent motions
  - S.C. Lee Comment on multiple probes
- Probes of initial conditions: non-Gaussinanity
  - J.W. Gong Cosmological test of GR using both WL and coherent motions
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- Constraints on neutrino mass
  - C.W. Kim Comment on neutrino mass
  - R. Nakajima Neutrino mass bound from weak lensing
  - Ultimate mass constraint using Lyman alpha forest commented by U.Seljak
- Structure formation at high redshift commented by K.J. Ahn
- Impact on Astrophysics: commented by C.B. Park

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Re-capturing cosmic information with log mapping

Hee-Jong Seo, Masanori Sato, Masahiro Takada, Scott Dodelson

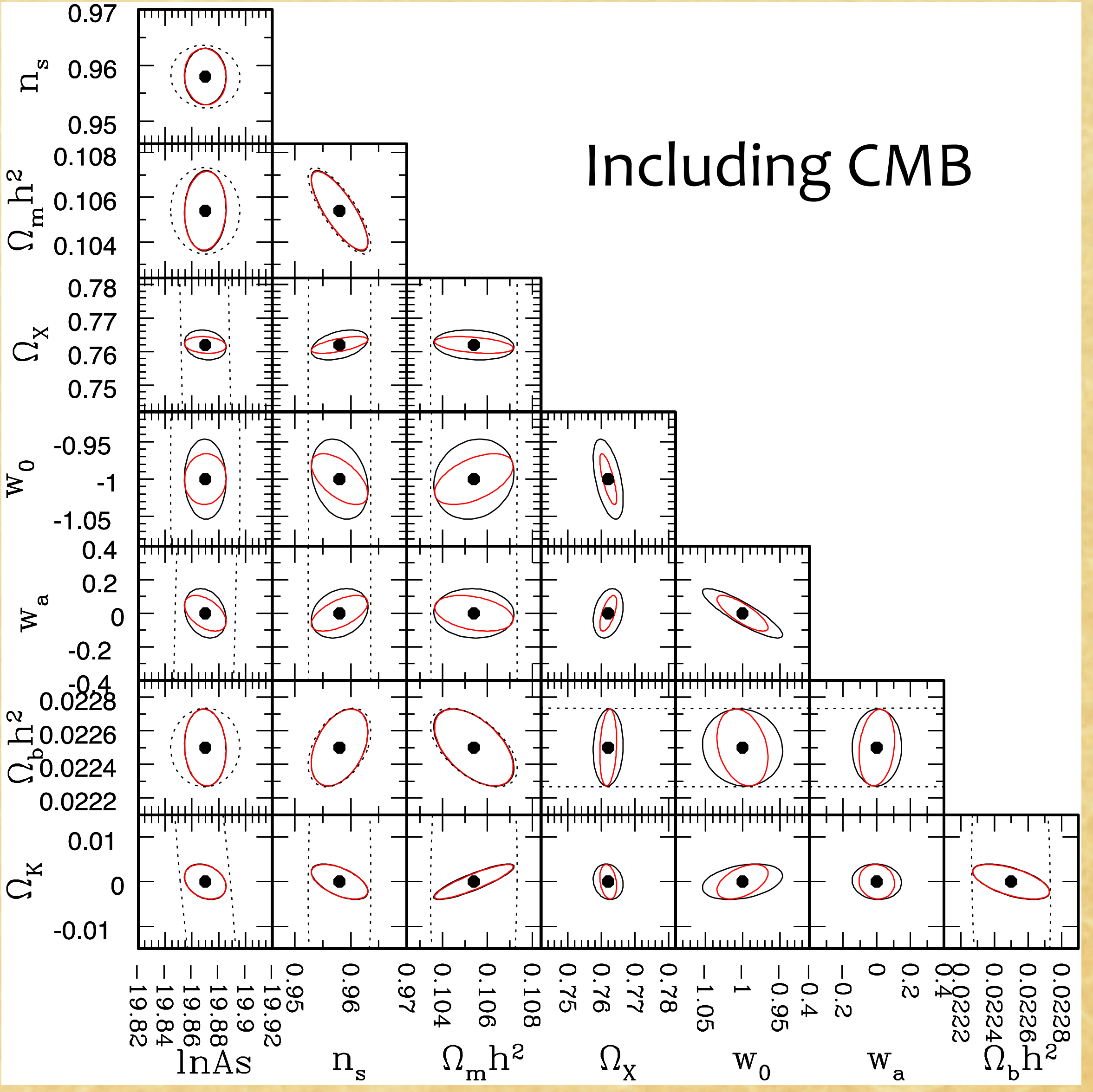
Convergence field

$$\kappa_{\ln}(\vec{\theta}) \equiv \kappa_0 \ln \left[1 + \frac{\kappa(\vec{\theta})}{\kappa_0} \right]$$

Increases S/N.
Decrease covariance between different scales.

Use N-body simulations as a function of cosmology,
And conduct a full Fisher matrix analysis.

1. Dark energy parameters are improved by the log-mapping.
2. Shape noise sharply decreases the improvement.



Galaxy intrinsic alignment and gravitational lensing

Jonathan Blazek, UC Berkeley

galaxy shape

$$\gamma^{obs} = \gamma^I + \gamma^G \quad \longrightarrow \quad \langle \gamma_i^{obs} \gamma_j^{obs} \rangle = \langle \gamma_i^G \gamma_j^G \rangle + \langle \gamma_i^I \gamma_j^G \rangle + \langle \gamma_i^G \gamma_j^I \rangle + \langle \gamma_i^I \gamma_j^I \rangle$$

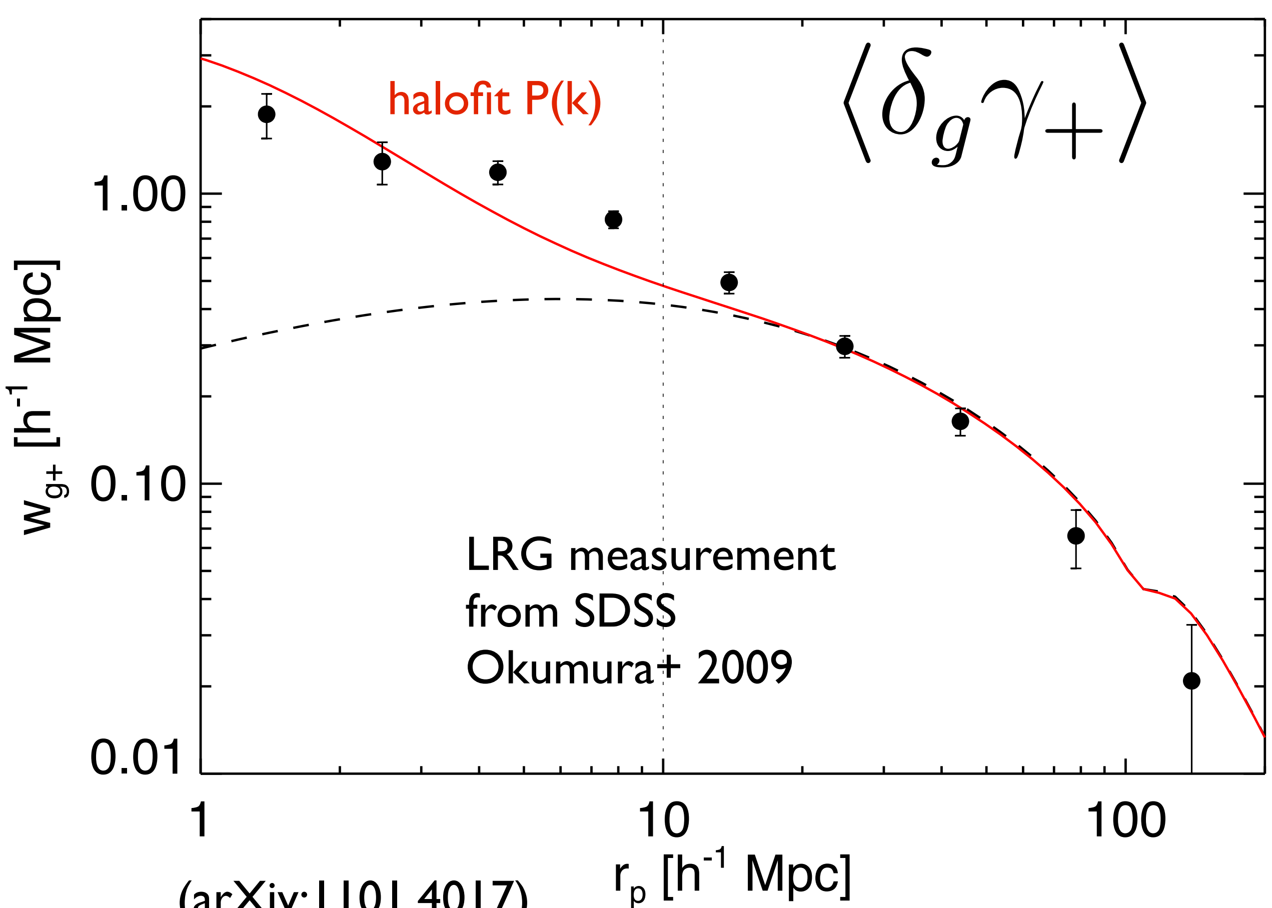
IA auto-correlation

cosmic shear signal

IA-lensing cross-correlation

Linear alignment model

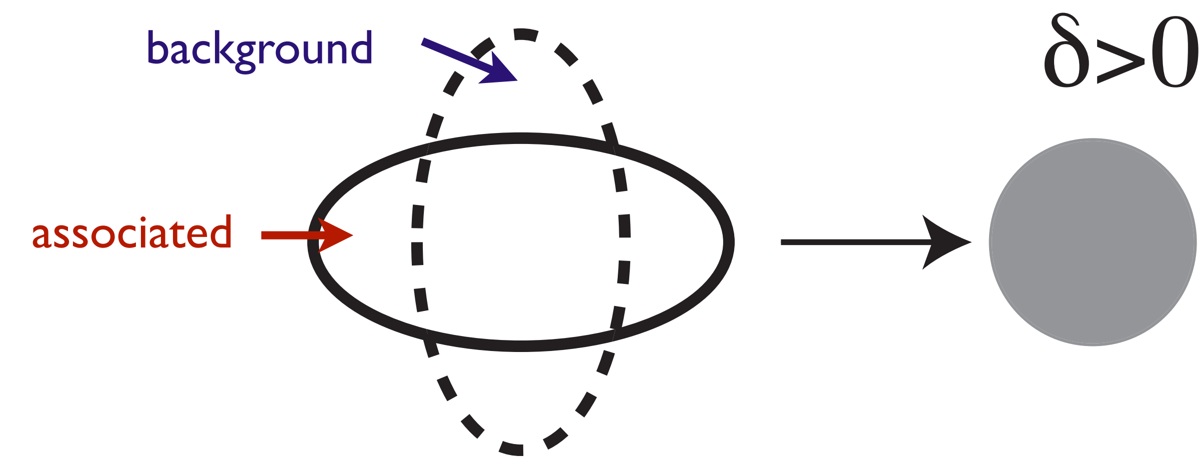
- galaxy ellipticity aligns with tidal field
- elliptical galaxies, large scales



(arXiv:1101.4017)

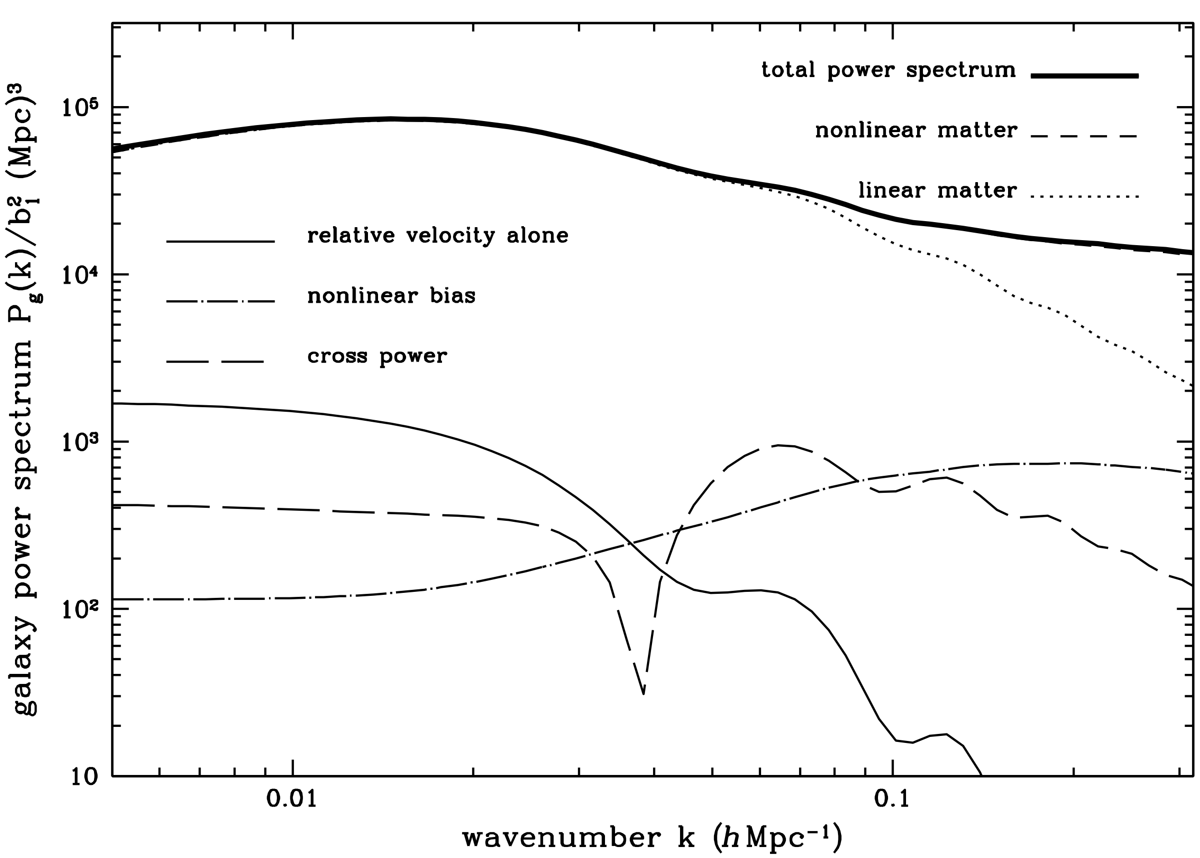
Photo-z galaxy-galaxy lensing

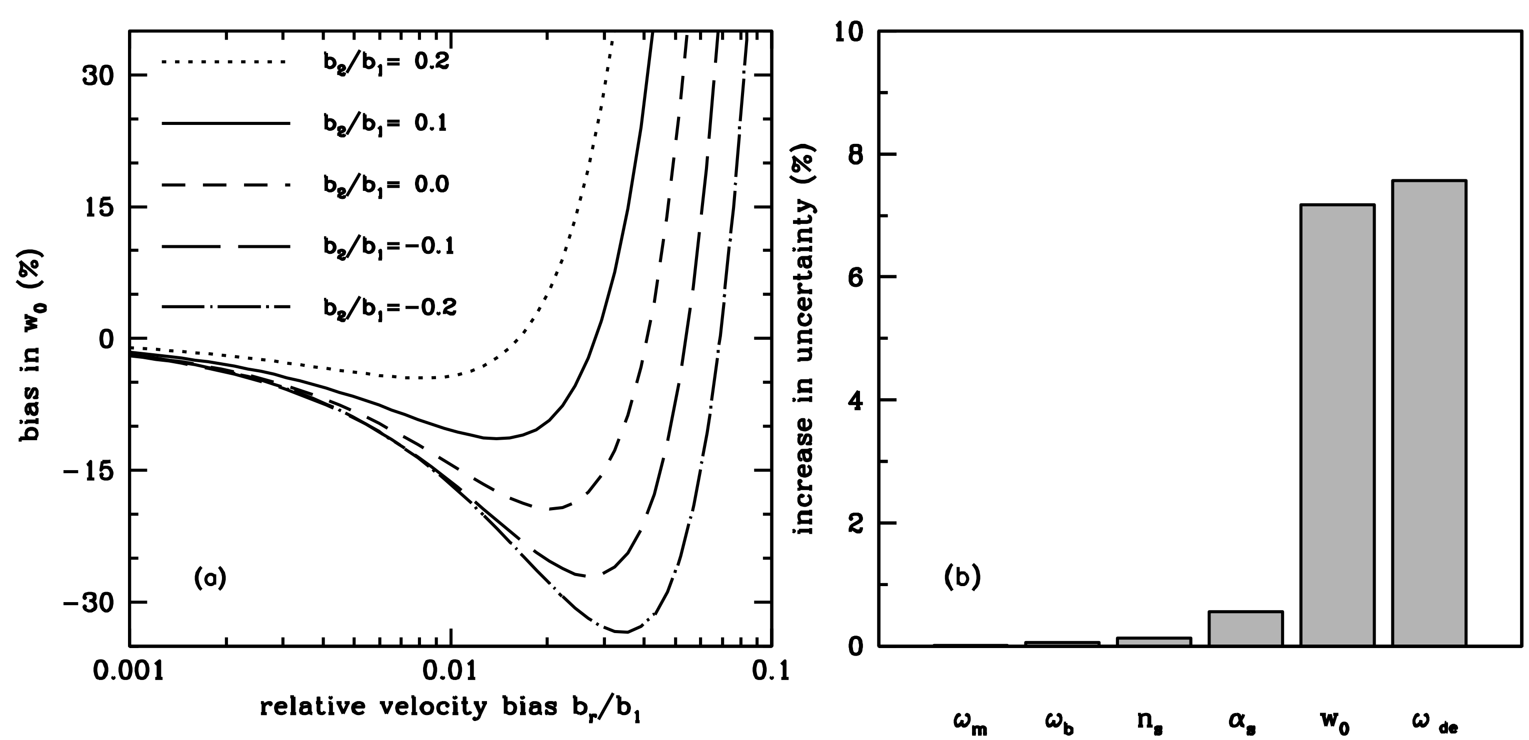
- photo-z uncertainty allows contamination from objects associated with lens
- we split source sample to constrain IA
- contamination up to ~10% of signal



SUPERSONIC RELATIVE VELOCITY EFFECT ON BAO MEASUREMENTS

- **Supersonic relative velocity effect:** **Tseliakhovich & Hirata, 2010, PRD**
  - **relative velocity between baryons and dark matter ~ 30 km/s at recomb. (c_s ~ 6 km/s)**
  - ***suppress* early halo abundance around Jeans scale**
- **Large scale BAO signature of smallest galaxies:** **Dalal, Pen & Seljak, 2011, JCAP**
  - **early halos are modulated by *relative velocity* not *matter density***
- **Impacts on low redshift BAO measurements:** **Yoo, Dalal & Seljak, 2011 JCAP**
  - $\delta_g = b_1\ \delta_m + \frac{1}{2}\ b_2\ [\delta_m^2 - \sigma_m^2] + \frac{1}{3!}\ b_3\ \delta_m^3 + b_r\ [v_r^2 - \sigma_r^2]$
  - **if ignored, relative velocity effect can *shift* BAO peak by ~ 10%**
  - **easy to model and marginalize over, error budget is inflated by only *8%* in w_0**
  - **bispectrum provides *unique* signature in a model independent way**



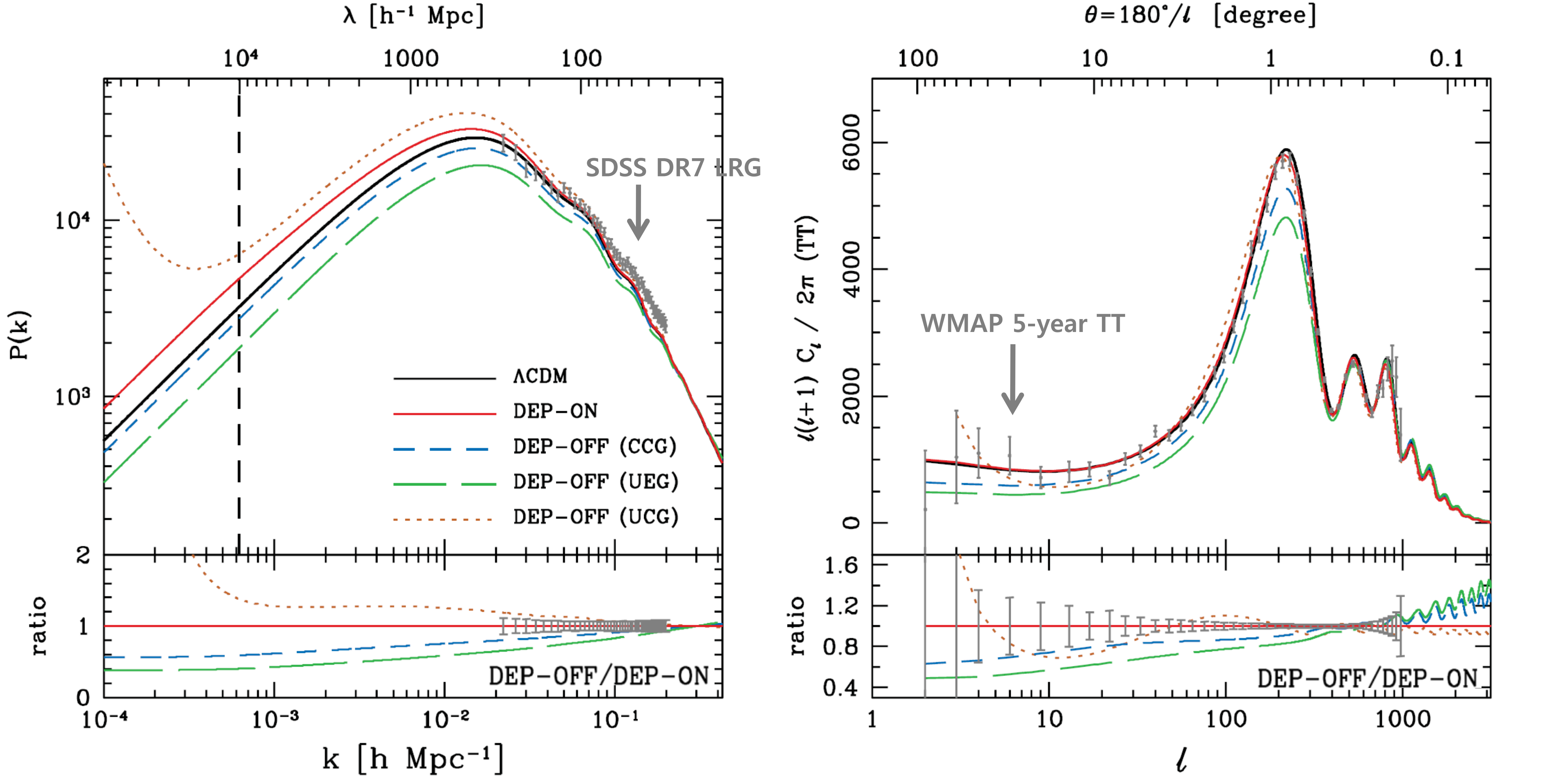


유재열 JAIYUL YOO

What happens if dark energy perturbation (DEP) is ignored?

C.-G. Park, J. Hwang, J. Lee, H. Noh, Phys. Rev. Lett. 103, 151303 (2009) [arXiv:0904.4007]

Quintessence with $V(\phi) = V_1 e^{-\lambda_1 \phi} + V_2 e^{-\lambda_2 \phi}$ (scaling initial conditions for λ_1=9.43; λ_2=1.0)



DEP-ON: All calculations are made in three different gauge conditions (CCG, UEG, and UCG). The results in the three gauges coincide exactly (red curves).

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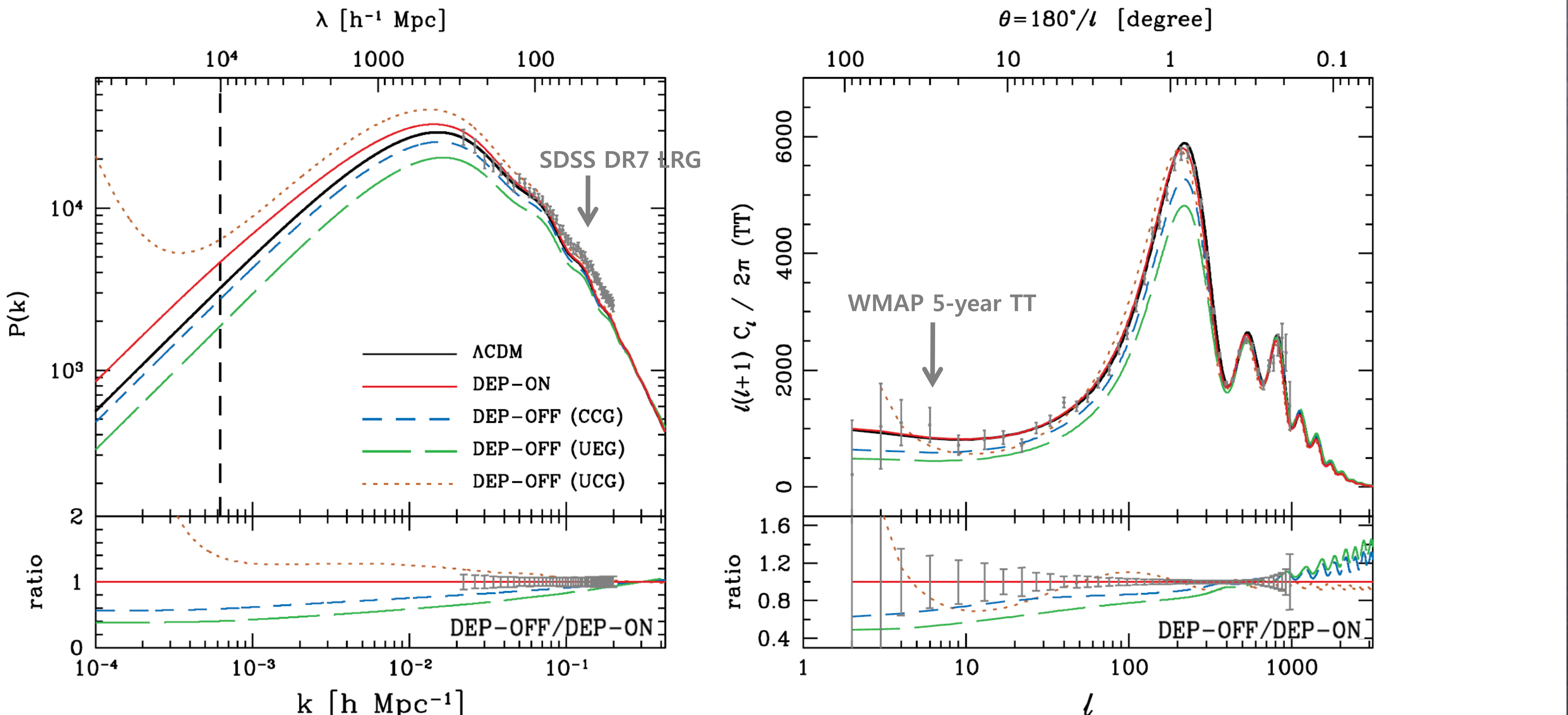

DEP-OFF: Cases when ***ignoring*** DE perturbation in the **CCG**, **UEG**, and **UCG.**

Observationally distinguishable substantial differences appear by ignoring DEP.

By ignoring it the perturbed system of equations becomes inconsistent and deviations in (gauge-invariant) power spectra depend on the gauge choice.

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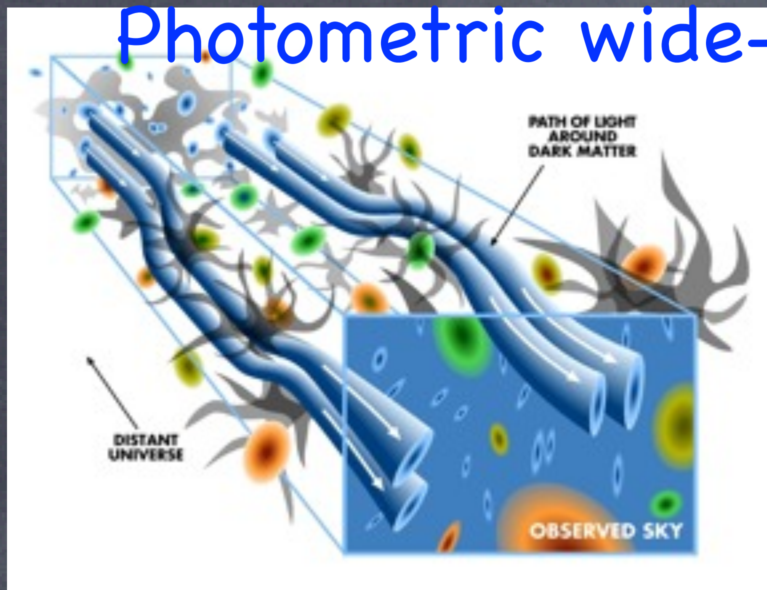
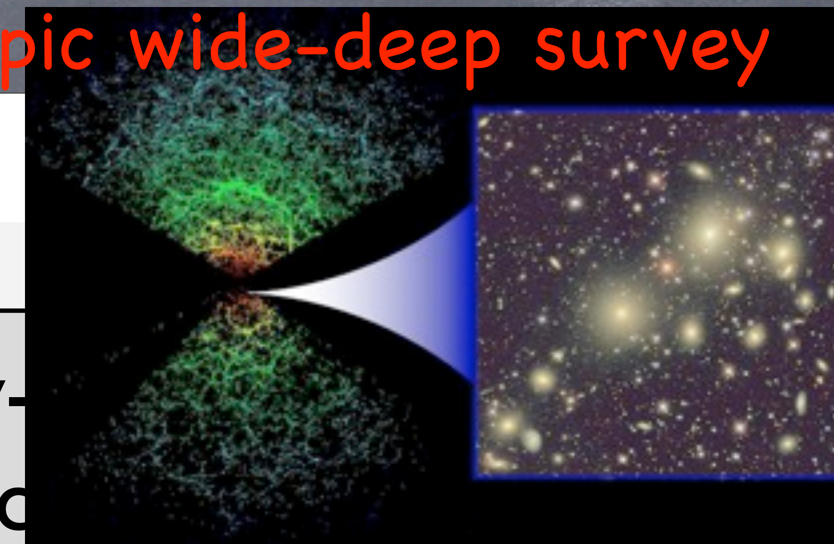
Yong-Seon Song

Cosmological Test of General Relativity

Photometric wide-deep survey



Spectroscopic wide-deep survey



urbations

Energy-
Fluc

WL measures Φ-Ψ

Modified by mass screening effect

Poisson equation

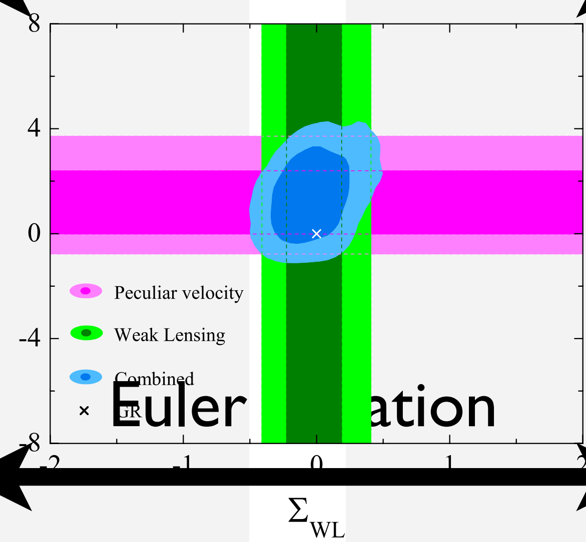
Φ

δ_m

Anisotropy

Geometrically induced

Continuity eq.



Euler ation

Ψ

θ_m

$$G_{\mu\nu} = 4\pi G_N T_{\mu\nu}$$

Coherent motions

Why do we need multiple probes ? : discriminate DE from MG

- Basic notations
  - Metric :

    $ds^2 = -(1+2\Psi)dt^2 + a^2(t)(1+2\Phi)d\vec{x}^2$
  - Anisotropic parameter : $\eta \equiv -\frac{\Phi}{\Psi}$
  - Peculiar velocity potential :

    $\mu \equiv -\frac{k^2\Psi}{4\pi G\rho_m a^2\delta}$
  - Growth factor of matter perturbation :

    $\Omega_m(a)^\gamma \equiv \frac{d\ln\delta}{d\ln a}$
  - $D \equiv \frac{\delta(a)}{\delta(a_i)}$ & $G \equiv \frac{D}{a}$

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  - : SZe, BAO : sensitive only to $H(a)$
  - : CMB : mostly insensitive to MG $\rightarrow \gamma$ turns on only in late Universe. (ISW effect and GL)
  - : WL & Cluster number : capture both H and G

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- simple static : $\chi^2(p_m) =$
  $\Sigma_i \Sigma_{m,n}(p_m - p_m^{(i)})[C^{(i)}]^{-1}_{mn}(p_n - p_n^{(i)})$
- parameter degeneracies :
  - SNe, BAO : $(\Omega_b, n_s, \sigma_8)$
  - CMB : $(\omega_0, \omega_a, \Omega_{de}, \Omega_k)$

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- Cluster number : $N_i = 4\pi f^{sky}\int_{z_i}^{z_i+1} dz \frac{\chi(z)^2}{H}\int_{M_{lim}}^{\infty} dM \times n(M,z)$ where $n(M,z) = -\frac{\rho_{c0}}{M}\frac{d\ln\sigma_M}{d\ln M}f(M,z)$
- Weak lensing : lensing convergence
  $\kappa_i(\theta) = \int_0^\infty d\chi\delta(\theta_\chi,\chi)W_i(\chi)$
  $< \bar{\kappa}_i(\vec{l})\kappa_j(\vec{l}') > \equiv (2\pi)^2\delta^2(\vec{l}+\vec{l}')C_{l;ij}$
  $C_{l;ij} = \int_0^\infty \frac{d\chi}{d_A(\chi)^2}W_iW_jP_\delta(k;\chi)$
  where $k \equiv \frac{l}{d_A(\chi)}$

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Early universe in LSS

LSS as a probe of early universe

How is LSS formed?

$$\mathscr{R} \rightarrow \Phi \rightarrow \delta$$

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$$\mathscr{R} \to \Phi \to \delta$$

1. Curvature perturbation $\mathscr{R}$
   - Generation and properties from microscopic physics
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   - Sachs-Wolfe limit $\Phi = 3\mathscr{R}/5$: Smaller scales?
   - Non-linear mapping: $\Phi = \phi + f_{\rm NL}\phi^2 + \cdots \to \mathscr{R} = \cdots$

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3. Density fluctuation δ
   - Properties of initial density field: Bias, (local) bispectrum...
   - Evolution: Volume effect, dark matter...
   - δ in which gauge?

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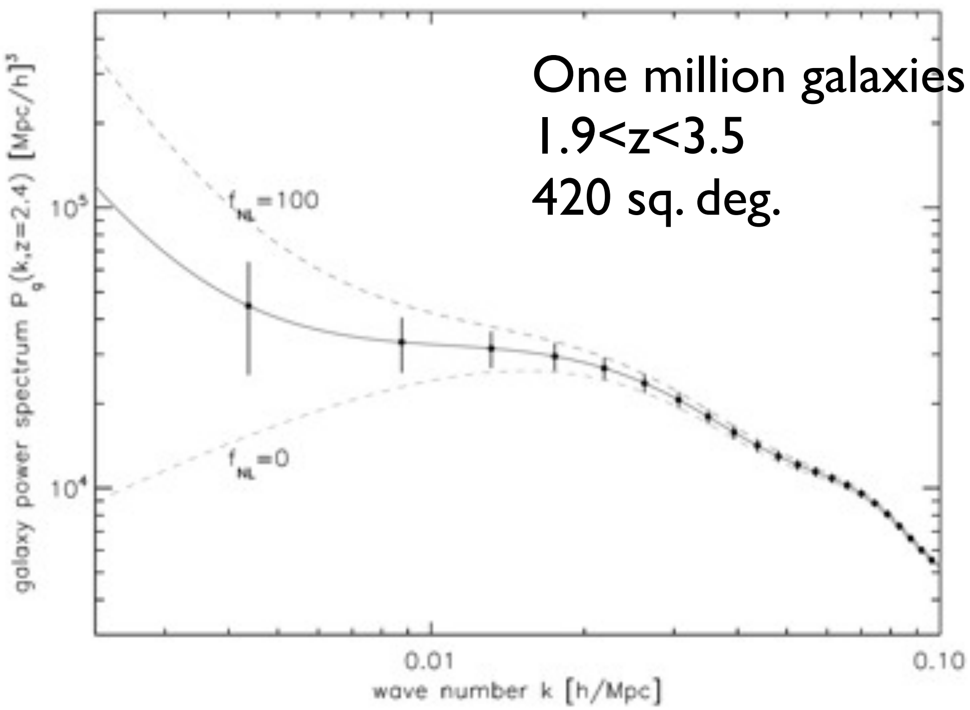
A consistent picture throughout the history of the universe?

Detecting f_{NL} from galaxy surveys

for HETDEX



A convincing detection of f_{NL}>1 would rule out ANY single field inflation models regardless of

- form of potential
- form of kinetic term
- initial vacuum state

$$P_g(k,\mu;z) = \left[\left(b+f\mu^2\right)^2 + 6 f_{\rm NL} b (b+f\mu^2)\tilde{\delta}_c \frac{H_0^2\Omega_m}{D(z)k^2T(k)}\right] D^2(z)P_L(k)$$

cf. Δf_{NL} for planck ~ 5

	z	V [Gpc/h]^3	n_g 10^{-5}[h/Mpc]^3	k_{max} [h/Mpc]	Δf_{NL} P(k)	Δf_{NL} Bk
SDSS LRG	0.315	1.48	136	0.1	41.80	5.62
BOSS	0.35	5.66	26.6	0.1	21.25	3.34
HETDEX	2.7	2.96	27	0.2	12.4	3.65
BigBOSS LRG	0.5	13.1	30	0.1	11.59	2.27
BigBOSS QSO	2.15	138.2	5	0.1	7.80	17.02
ADEPT	1.5	107.3	93.7	0.1	2.73	1.11
EUCLID	1.0	102.9	156	0.1	3.70	0.92

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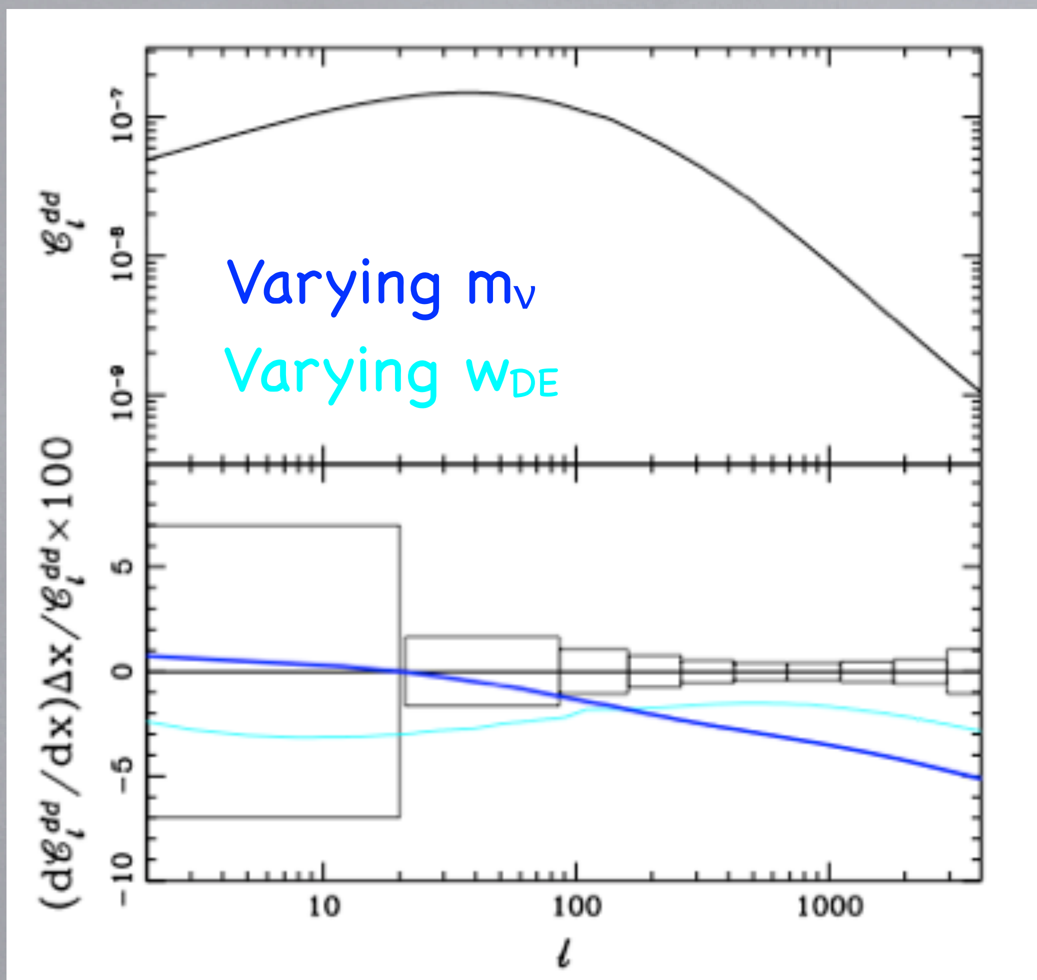
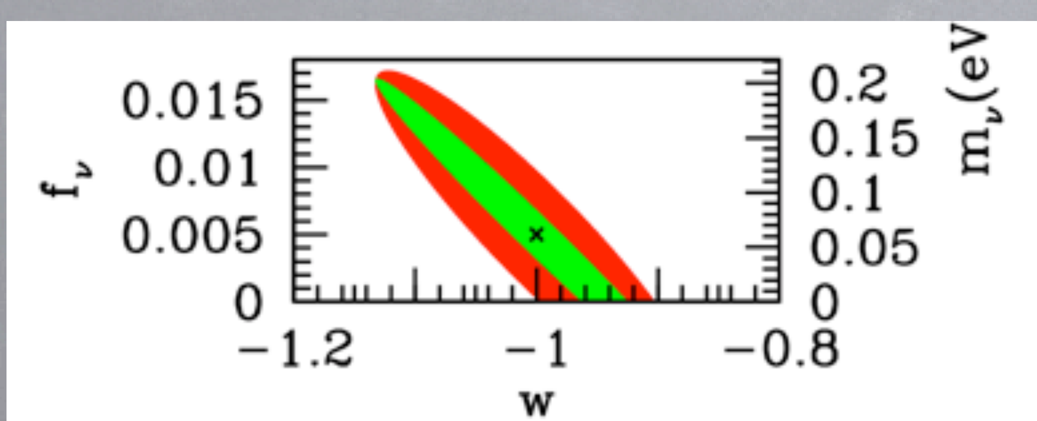
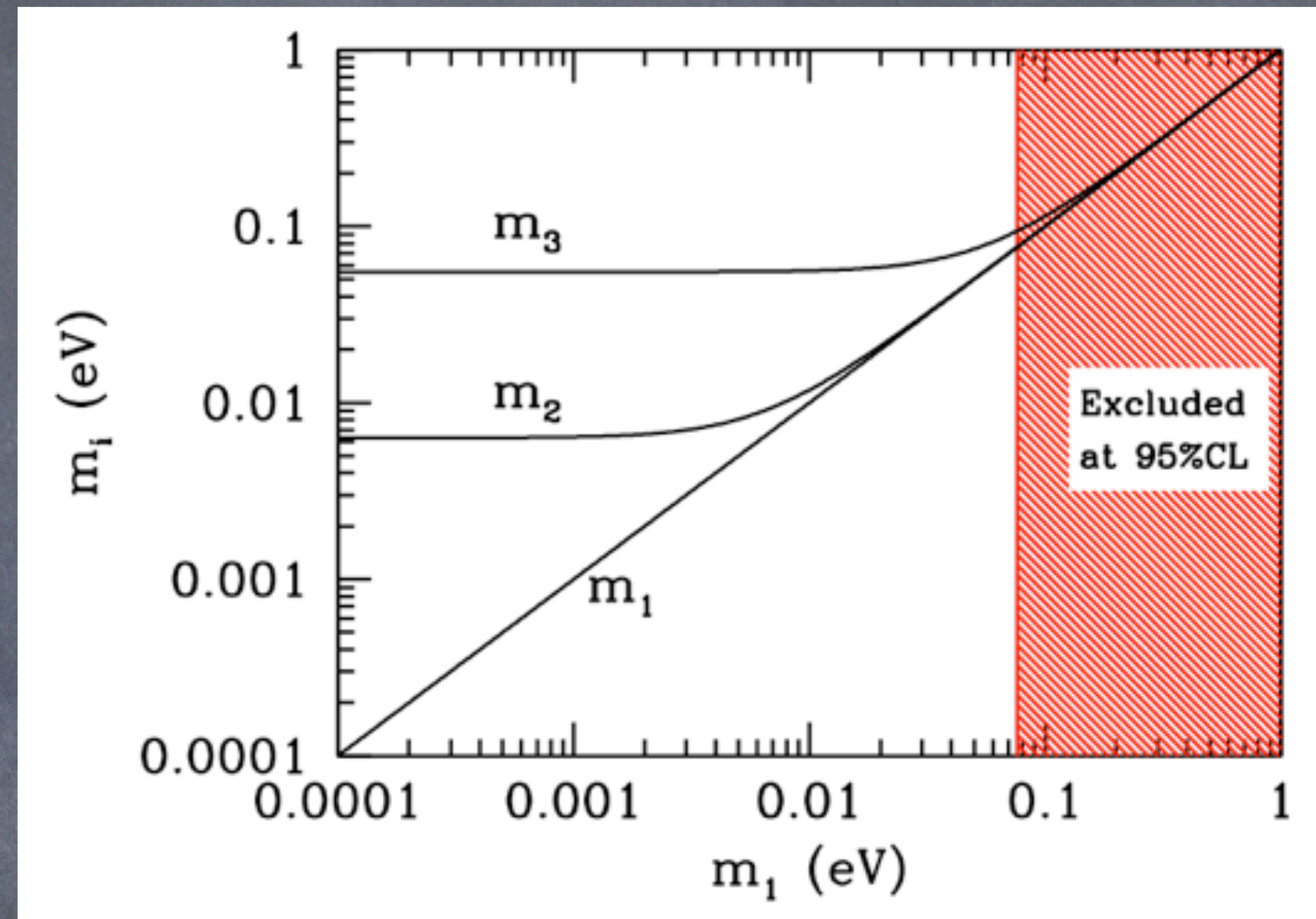
C.W. Kim

Constraint on neutrino mass using WL

R. Nakajima

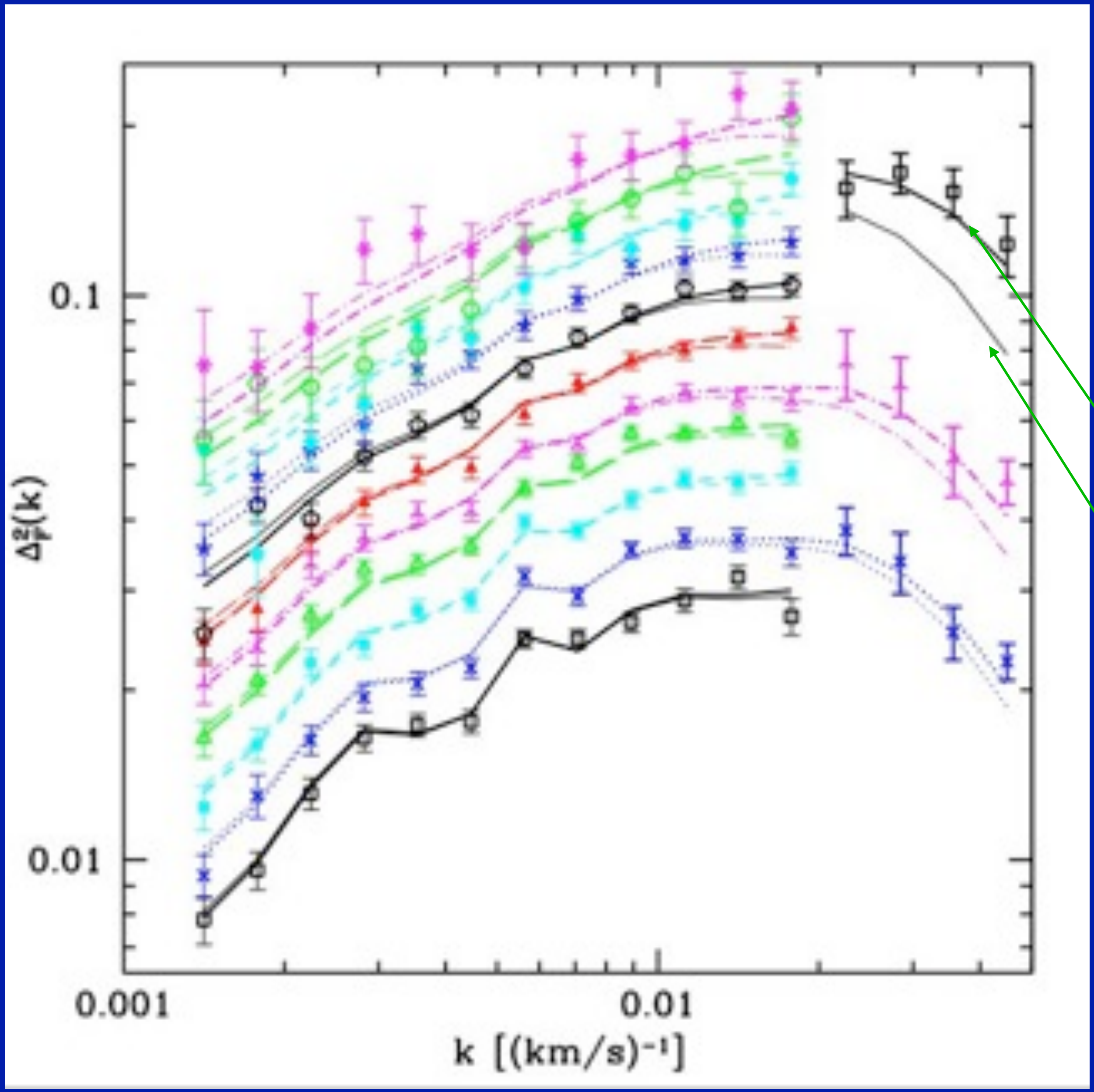






Bound on m_ν using WL is $\Delta m_\nu < 0.1$ eV ?

SDSS and high resolution Lya power spectrum analysis



McDonald, Seljak etal 2006

- 2<z<4 in 11 bins
- **A single CDM model fits the data over a wide range of redshift and scale**
- **WDM (6.5keV) does not fit**

Limits on neutrino mass

Seljak, McDonald, Slosar 2007

Lya+SDSS+2dF+SN 6p:

$$\sum m_\nu < 0.17eV\,(95\%) \quad < 0.32eV\,(99.9\%)$$

$$\Delta m_{12}^2 = 8 \times 10^{-5} eV^2,\ \Delta m_{23}^2 = 2.5 \times 10^{-3} eV^2$$

$$m_1 < 0.05eV,\ m_2 < 0.05eV,\ m_3 < 0.07eV$$

$$\frac{m_3}{m_1} > 1.3(95\%)$$

$$\sum m_\nu < 0.26eV\,(95\%cl)$$

Estimation from future Lyman α experiment

From Big-Boss $\Sigma m_\nu = 0.05 \pm 0.024$ eV

	Σm_ν [eV]	ΣN_ν
Fiducial values	0.05	3.04
$\sigma-$ Planck+BAO(LyaF+galaxies)	0.094	0.18
$\sigma-$ Planck+BAO(LyaF+galaxies)+nBAO(galaxies)	0.039	0.097
$\sigma-$ Planck+BAO(LyaF+galaxies)+nBAO(LyaF)	0.031	0.056
$\sigma-$ Planck+BAO(LyaF+galaxies)+nBAO(galaxies+LyaF)	0.024	0.056

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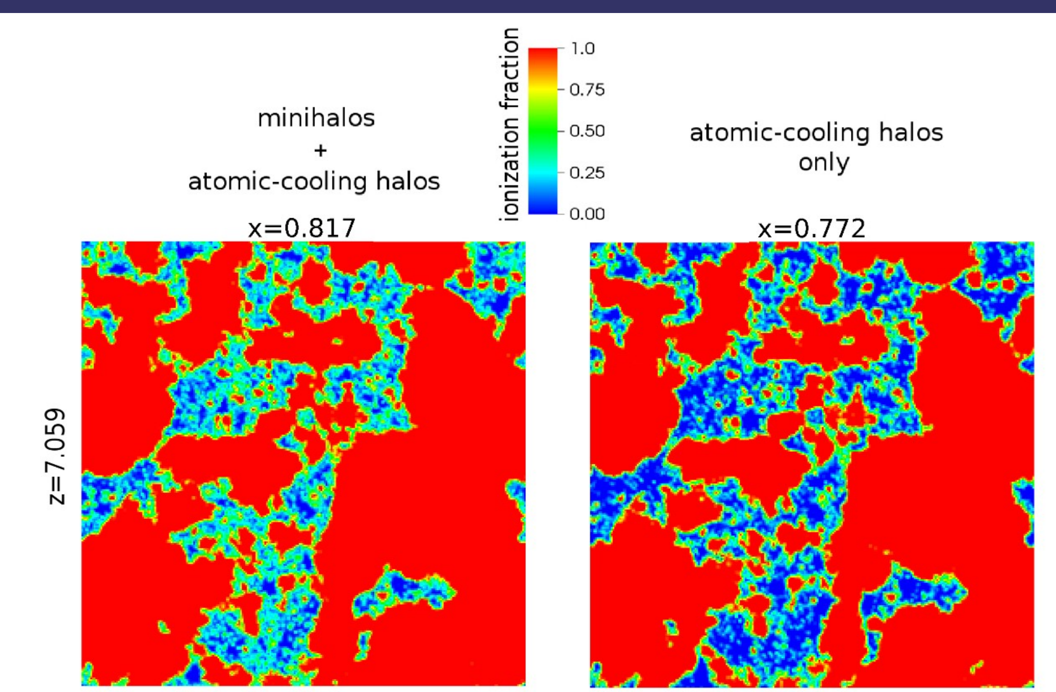
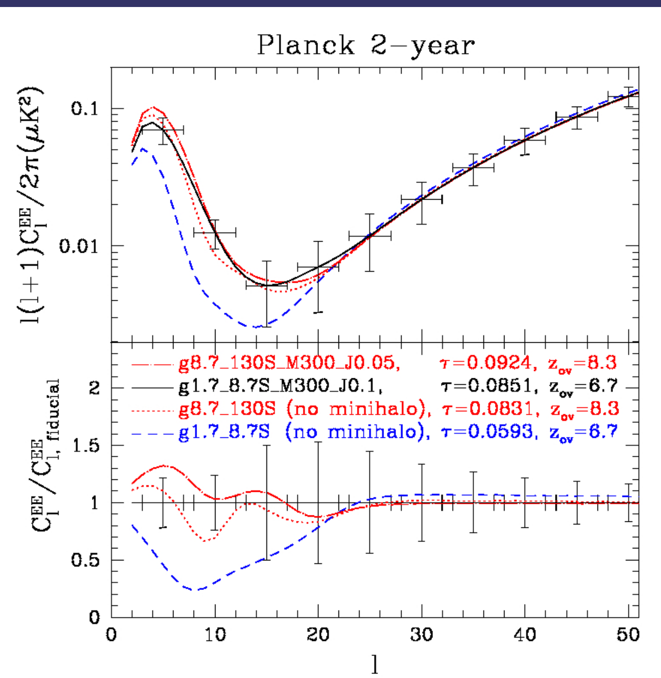
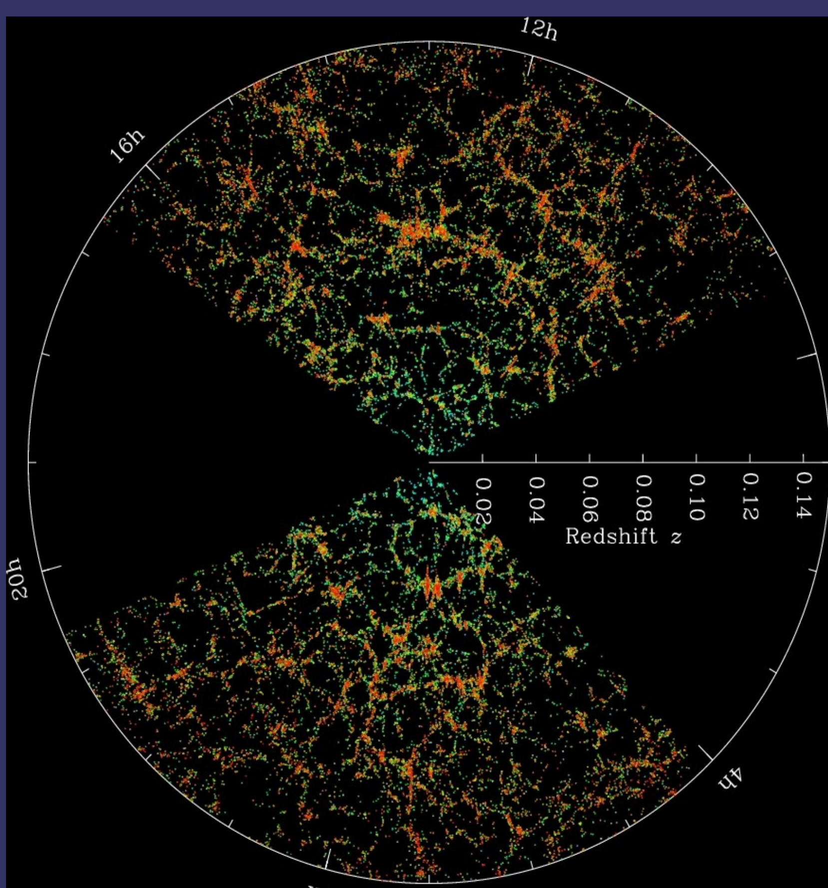
Kyungjin Ahn

Hydrodynamic Effects from High-Redshift Objects

- ➲ When & how big impacts by high-z sources
- ➲ Survey interpretation may alter → estimate!
  - Direct impact on matter distribution
  - Additional bias of survey targets







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Impact on Astrophysics

- Photometric survey: advantage to research diverse characteristics of galaxies. As it targets higher redshift, it reveals the evolution of galaxies in detail.

- Spectroscopic survey: advantage to research chemical compounds and dynamical states of galaxies, and inner mechanism and estimated mass of cluster.

- Photometric + Spectroscopic + redshift information: lead to ideal combination to study detailed evolution of diverse characteristics of galaxies.

Conclusion

- Dark energy prospect: multiple probes strategy
  - H.J. Seo Re-capturing cosmic information with log mapping
  - J. Blazek Galaxy intrinsic alignment and gravitational lensing
  - J.Y. Yoo Supersonic relative velocity effect on BAO measurements
  - C.-G. Park What happens if dark energy perturbation is ignored?
- Is acceleration caused by modified gravity instead?
  - Y.S. Song Cosmological test of GR using both WL and coherent motions
  - S.C. Lee Comment on multiple probes
- Probes of initial conditions: non-Gaussinanity
  - J.W. Gong Cosmological test of GR using both WL and coherent motions
  - D.H. Jeong Detecting fNL from galaxy surveys
- Constraints on neutrino mass
  - C.W. Kim Comment on neutrino mass
  - R. Nakajima Neutrino mass bound from weak lensing
  - Ultimate mass constraint using Lyman alpha forest commented by U.Seljak
- Structure formation at high redshift commented by K.J. Ahn
- Impact on Astrophysics: commented by C.B. Park


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