Title: The ISW Effect as a Probe of Dark Energy

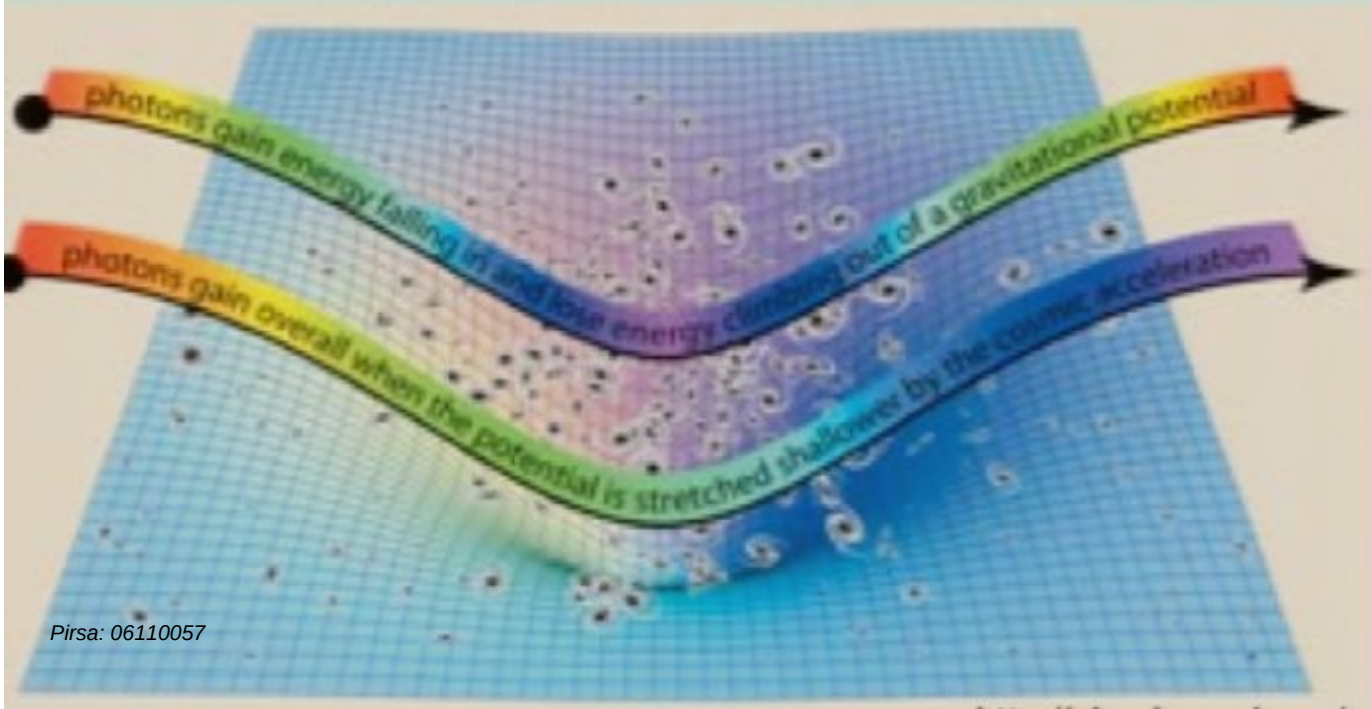
Date: Nov 11, 2006 04:30 PM

URL: http://pirsa.org/06110057

Abstract:

Probing dark energy with the ISW effect

Levon Pogosian
Simon Fraser University



with
P.-S. Corasaniti
R. Crittenden
B. Nichol
C. Stephan-Otto

Integrated Sachs-Wolfe effect

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$\Omega = \Omega_M$

blueshift = redshift

Integrated Sachs-Wolfe effect

$\Omega = \Omega_M$

blueshift = redshift

$\Omega \neq \Omega_M$

blueshift ≠ redshift

Integrated Sachs-Wolfe effect

$$\Delta^{ISW}(\hat{n}) \approx -2\int dz \; \frac{d\Phi[r(z)\hat{n}, z]}{dz}$$

Integrated Sachs-Wolfe effect

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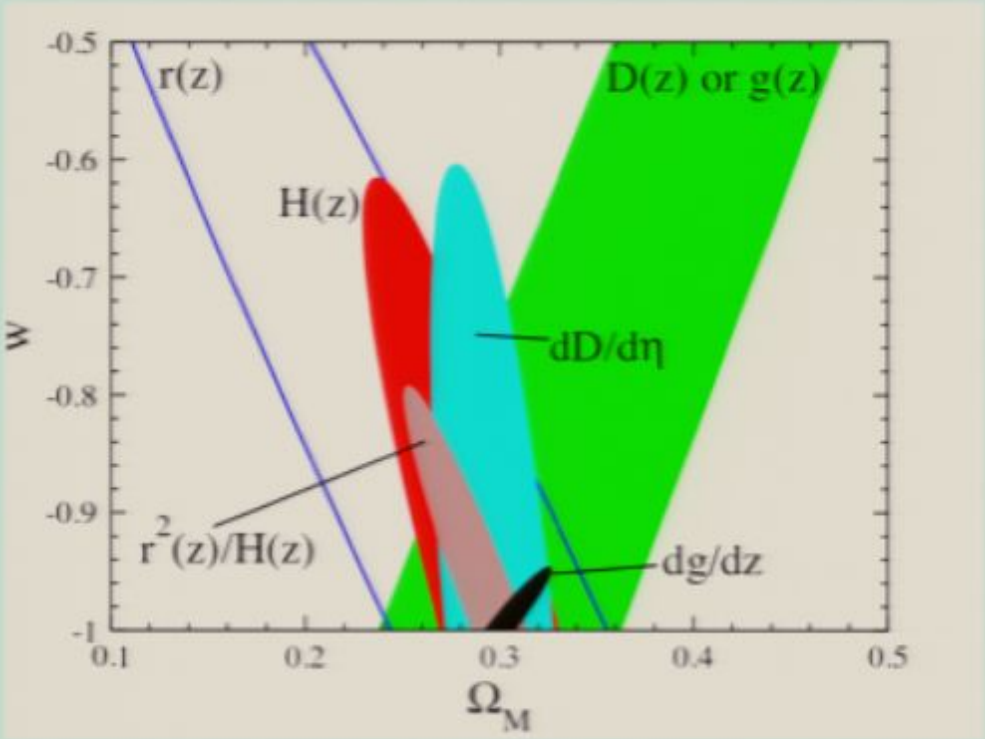
Growth factor

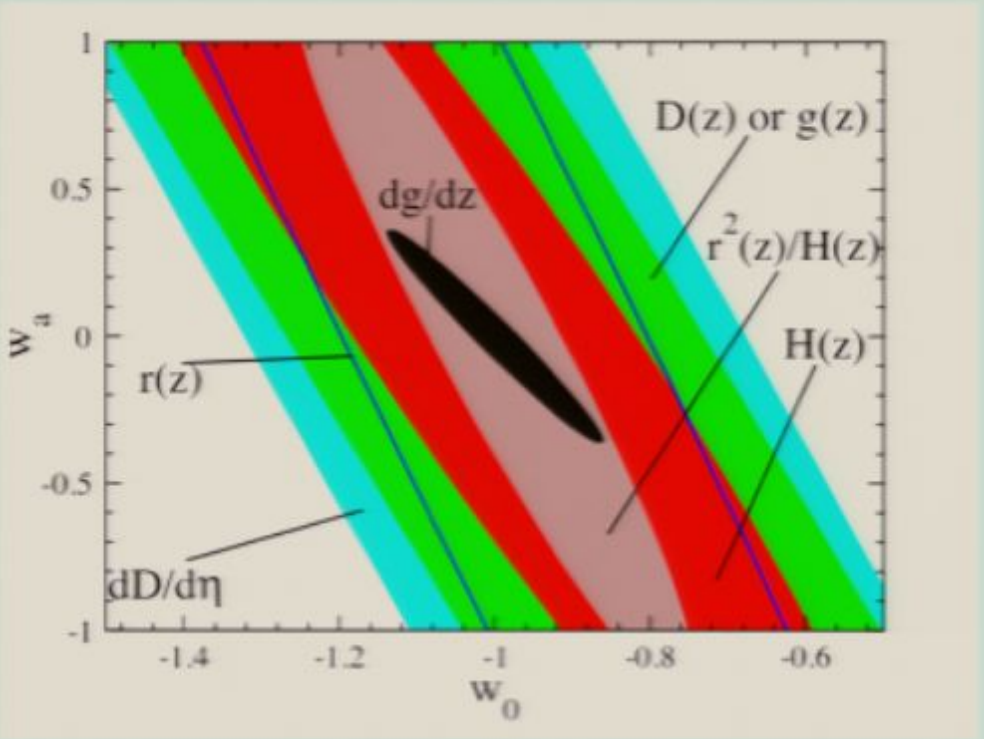
$$D(z) \equiv \frac{\delta_k(z)}{\delta_k(0)}$$

Growth Rate

$$\frac{d\Phi}{dz} \propto \frac{d}{dz}\left[(1+z)D(z)\right] \equiv \frac{dg}{dz}$$

Growth rate vs other probes





"Growth Rate of Large Scale Structure as a Powerful Probe of Dark Energy"
Cooray, Huterer & Baumann, astro-ph/0304268

Why?

Why?

$$2\frac{d^2 g}{d\ln a^2}+[5-3w(a)\Omega_{DE}(a)]\frac{dg}{d\ln a}+3[1-w(a)]\Omega_{DE}(a)g=0$$

Cooray, Huterer & Baumann, astro-ph/0304268

Why?

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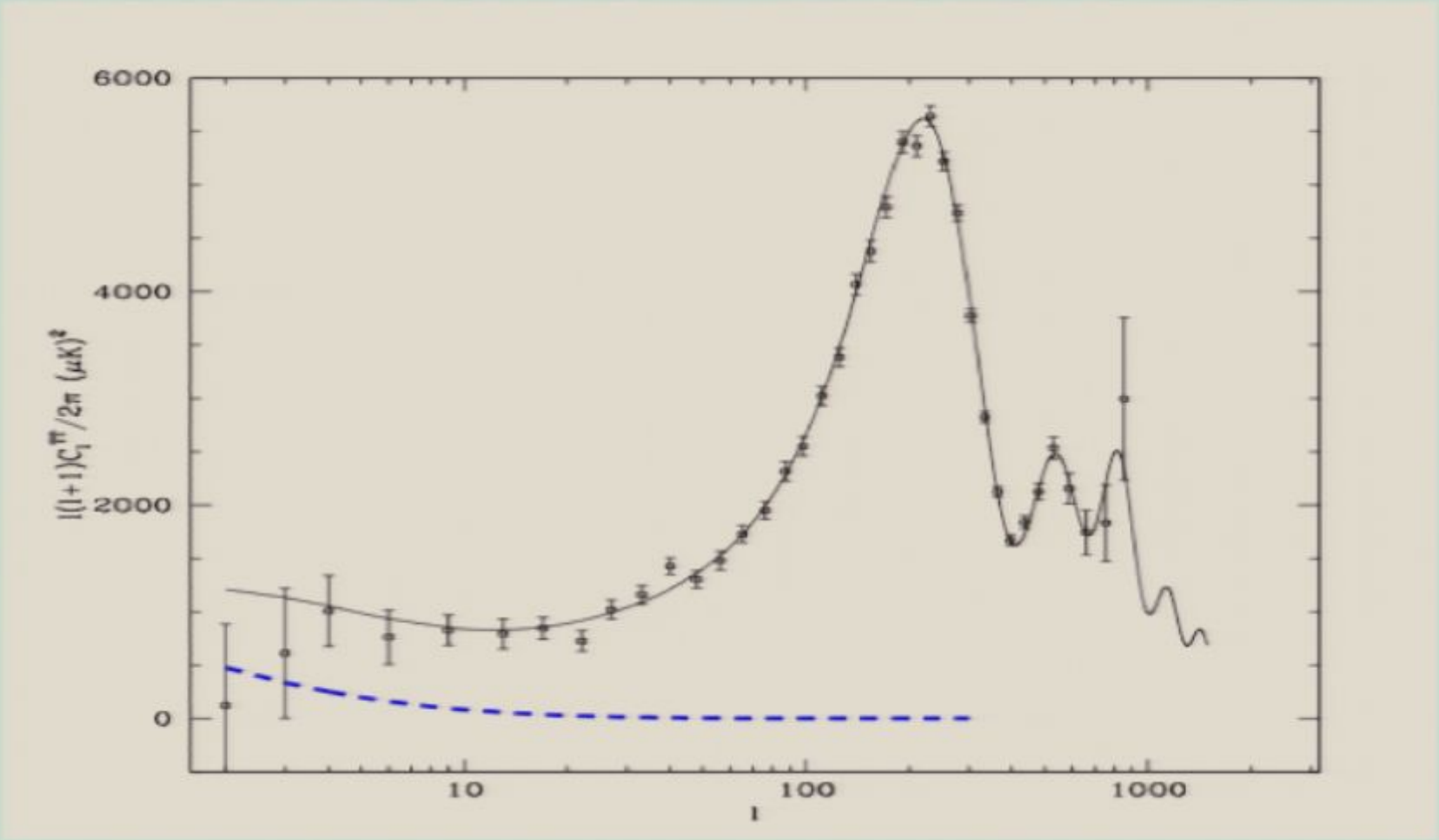
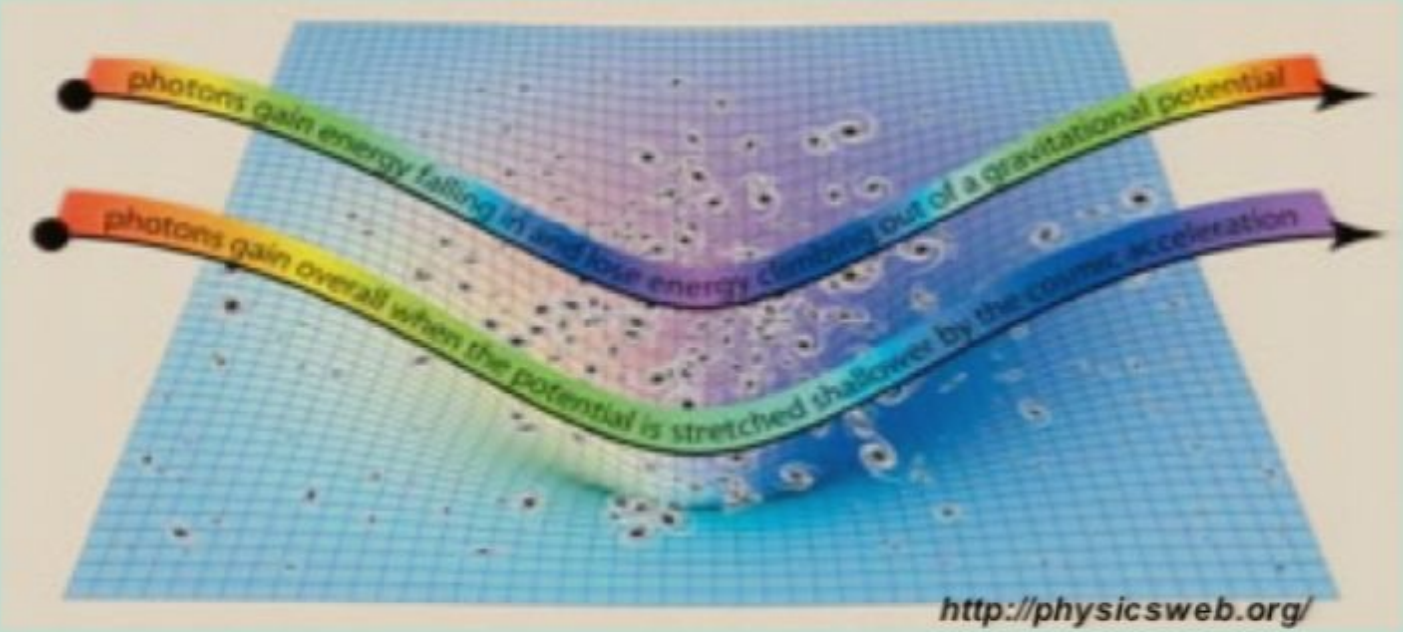
Cooray, Huterer & Baumann, astro-ph/0304268

$$\ddot{\delta}_k+2H\dot{\delta}_k-4\pi\rho_M\delta_k=0$$

Integrated Sachs-Wolfe effect



LSS and ISW are correlated



Crittenden & Turok, PRL96, astro-ph/9510072

Current CMB/LSS correlation detection

WMAP1 / **2MASS:** **Afshordi et al,** astro-ph/0308260

WMAP1 / **APM:** **Fosalba and Gaztanaga,** astro-ph/0305468

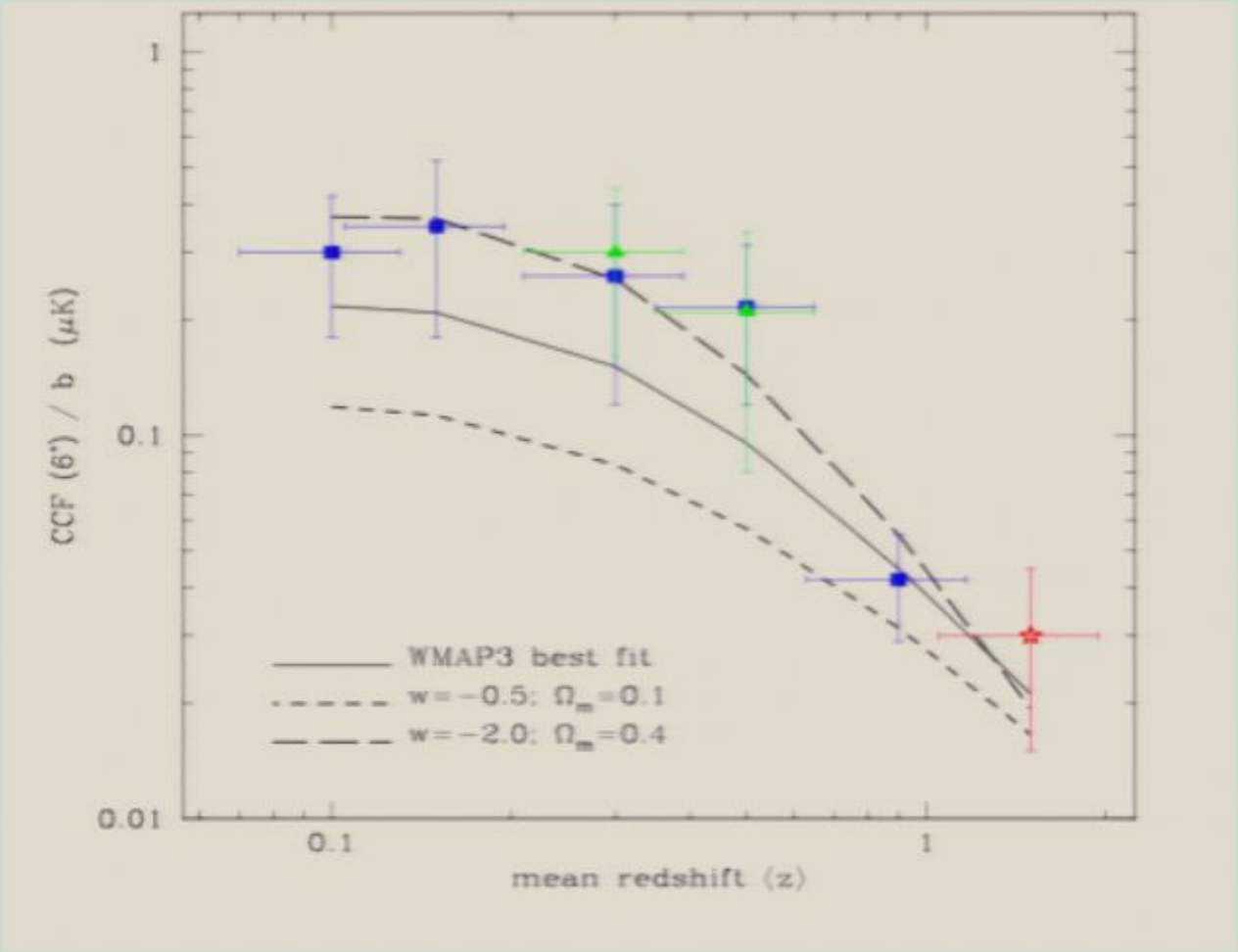
WMAP1 / **SDSS:** **Fosalba et al,** astro-ph/0307249
Scranton et al, astro-ph/0307335
N. Padmanabhan et al, astro-ph/0410360
A. Cabre et al, astro-ph/0603690

WMAP1 / **NVSS:** **Boughn and Crittenden**, astro-ph/0305001
Nolta et al, astro-ph/0305097
Vielva et al, astro-ph/0408252
McEwen et al, astro-ph/0602398

WMAP1 / **HEAO-1**: **Boughn and Crittenden**, astro-ph/0305001

WMAP3 / **SDSS high-z quasars:** **Giannantinio et al,** astro-ph/0607572

Current data



From Giannantonio et al, astro-ph/0607572

CMB/LSS correlation

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$$T(\hat{n}) \rightarrow TT \rightarrow C_l$$

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$$TM \longrightarrow X_l$$

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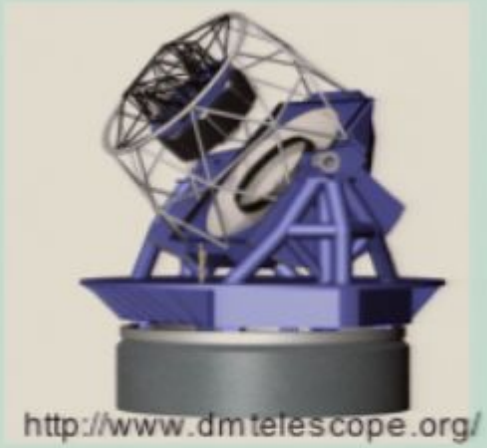
$$TM \longrightarrow X_l$$

$$\left(\frac{S}{N}\right)_l^2 \approx \frac{f_{sky}(2l+1)}{4\pi} \frac{X_l^2}{C_l M_l}$$

Future


http://www.dmtelescope.org/

LSST

50 gal/arcmin^2

20,000 deg^2

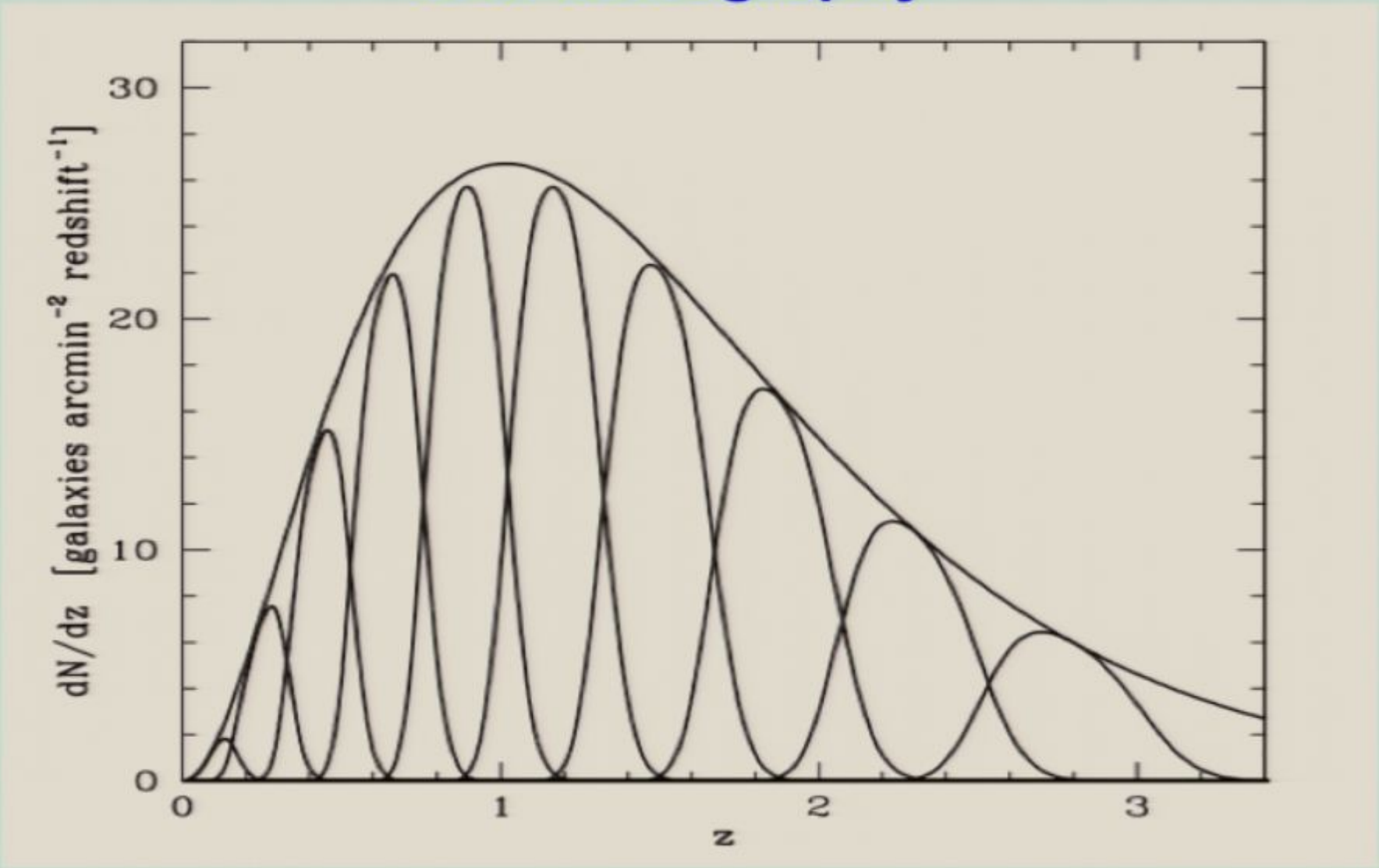
10 photometric bins, $z_{max} \approx 3$

http://sci.esa.int/

Planck

CMB temperature and polarization

ISW tomography



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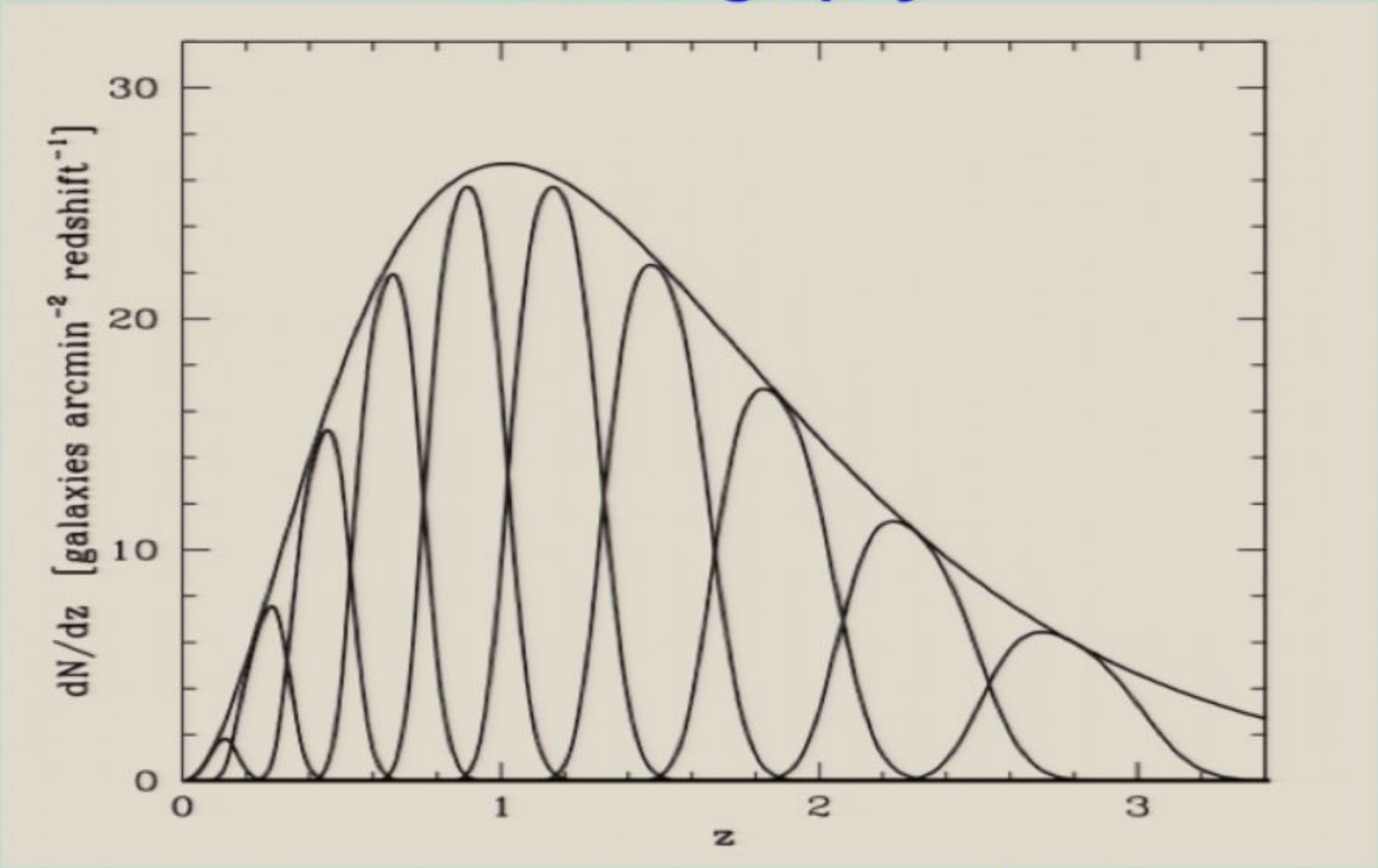
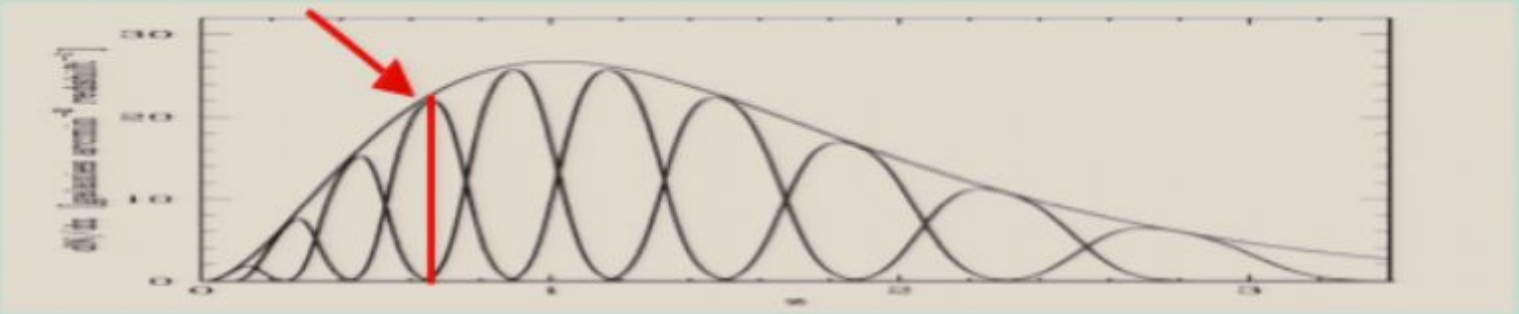
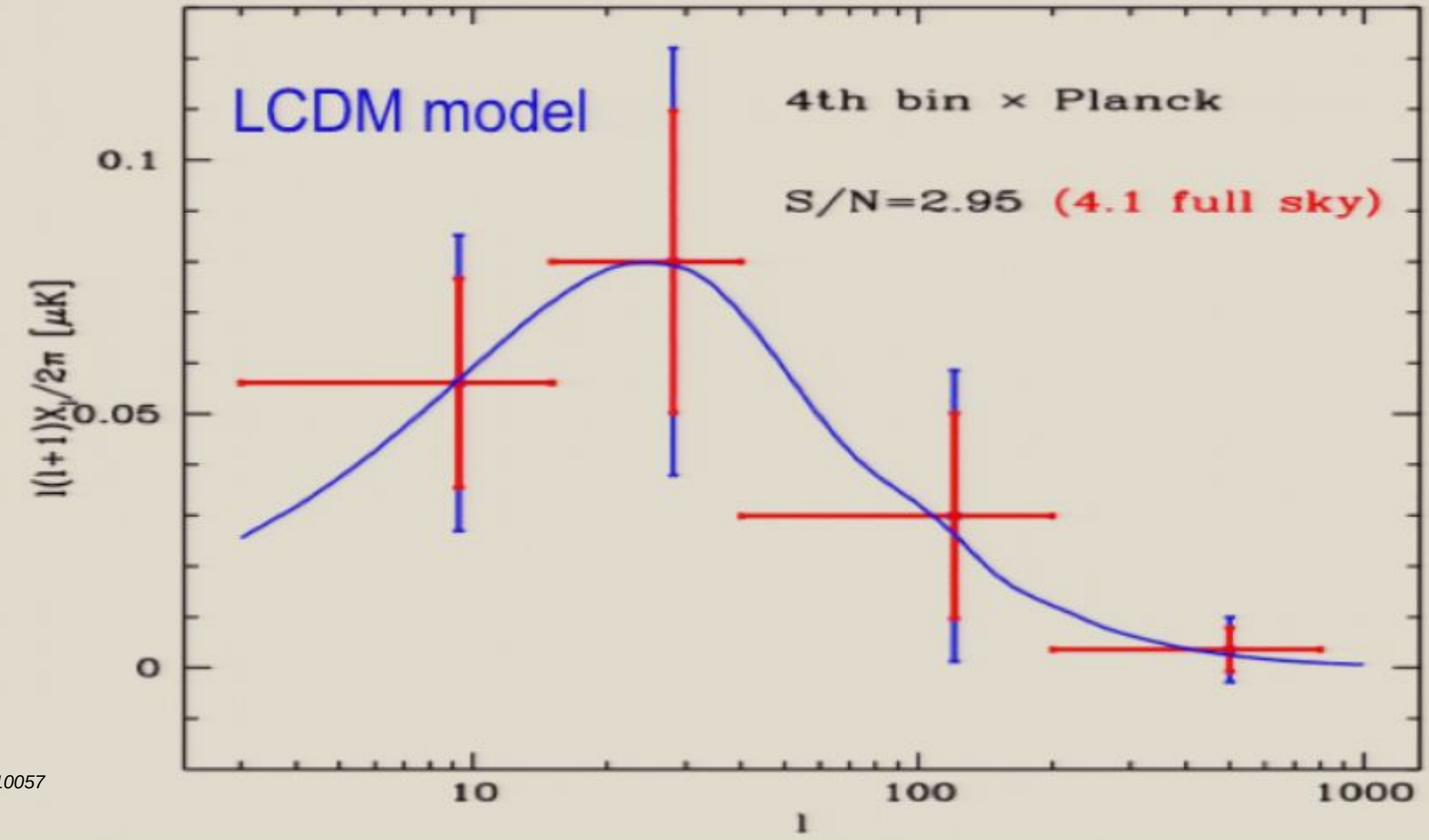


$$X \propto \int dz\ [geom.factor]\ W(z,z^*)\ D(z)\ \frac{d}{dz}\left[D(z)(1+z)\right]$$

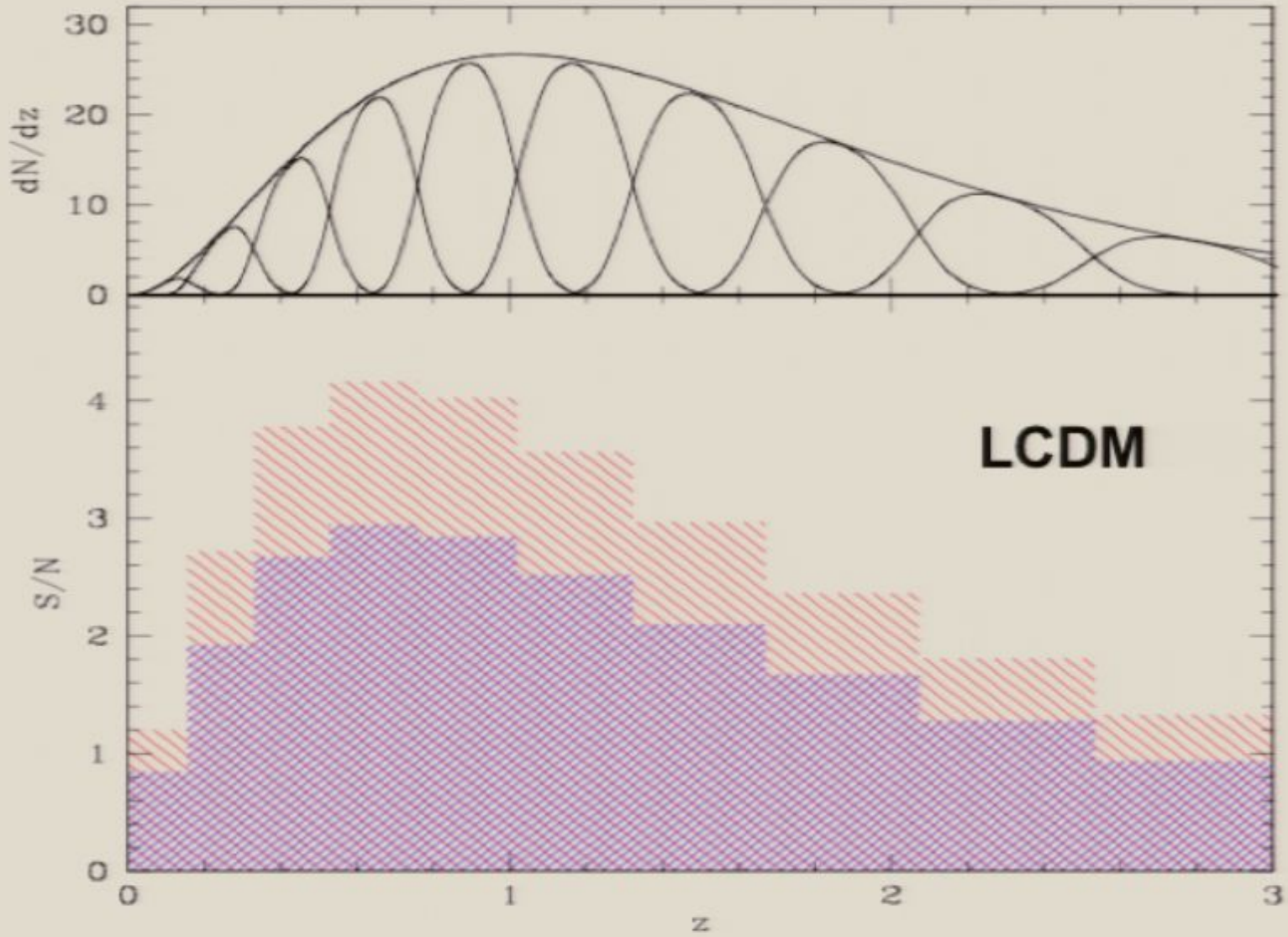
$l(l+1)X_l/2\pi$



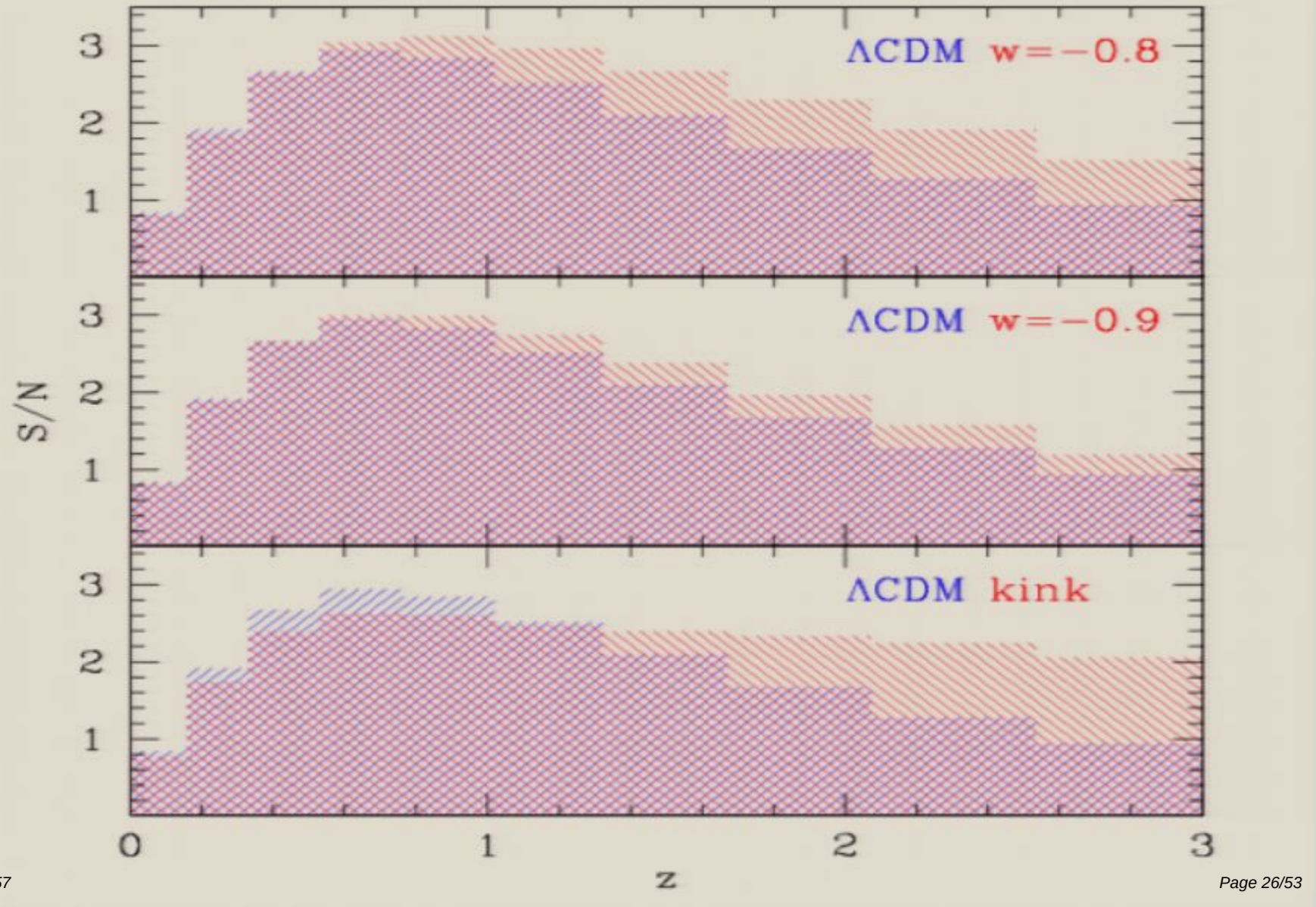
<z>~0.6



S/N



Other models (with same CMB TT)



Precision cosmology with S/N<10?

factor ~ 10 better sensitivity to DE properties

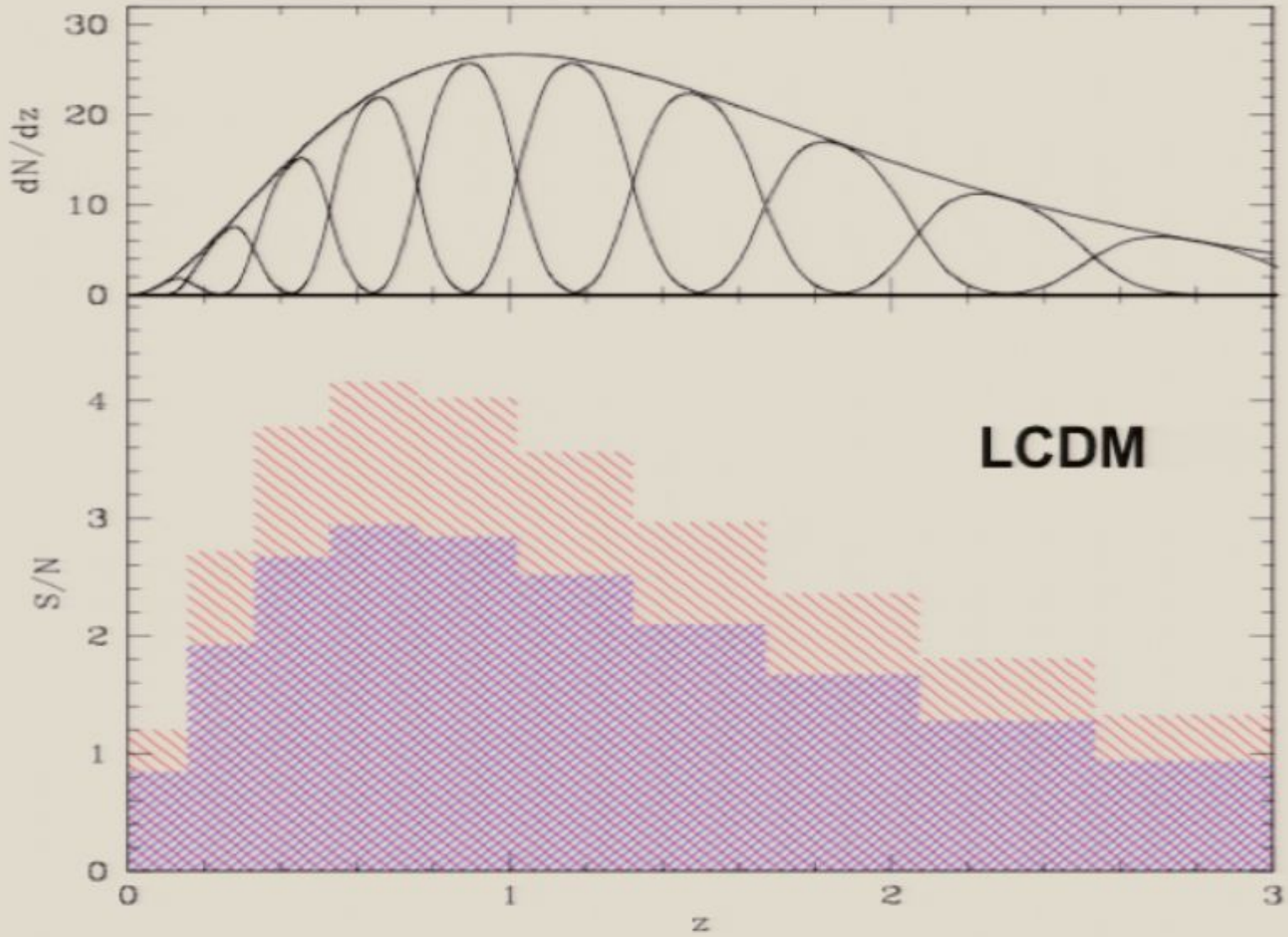
probes large (linear) scales

linear dependence on bias

goes deep in z

independent of τ and r

S/N



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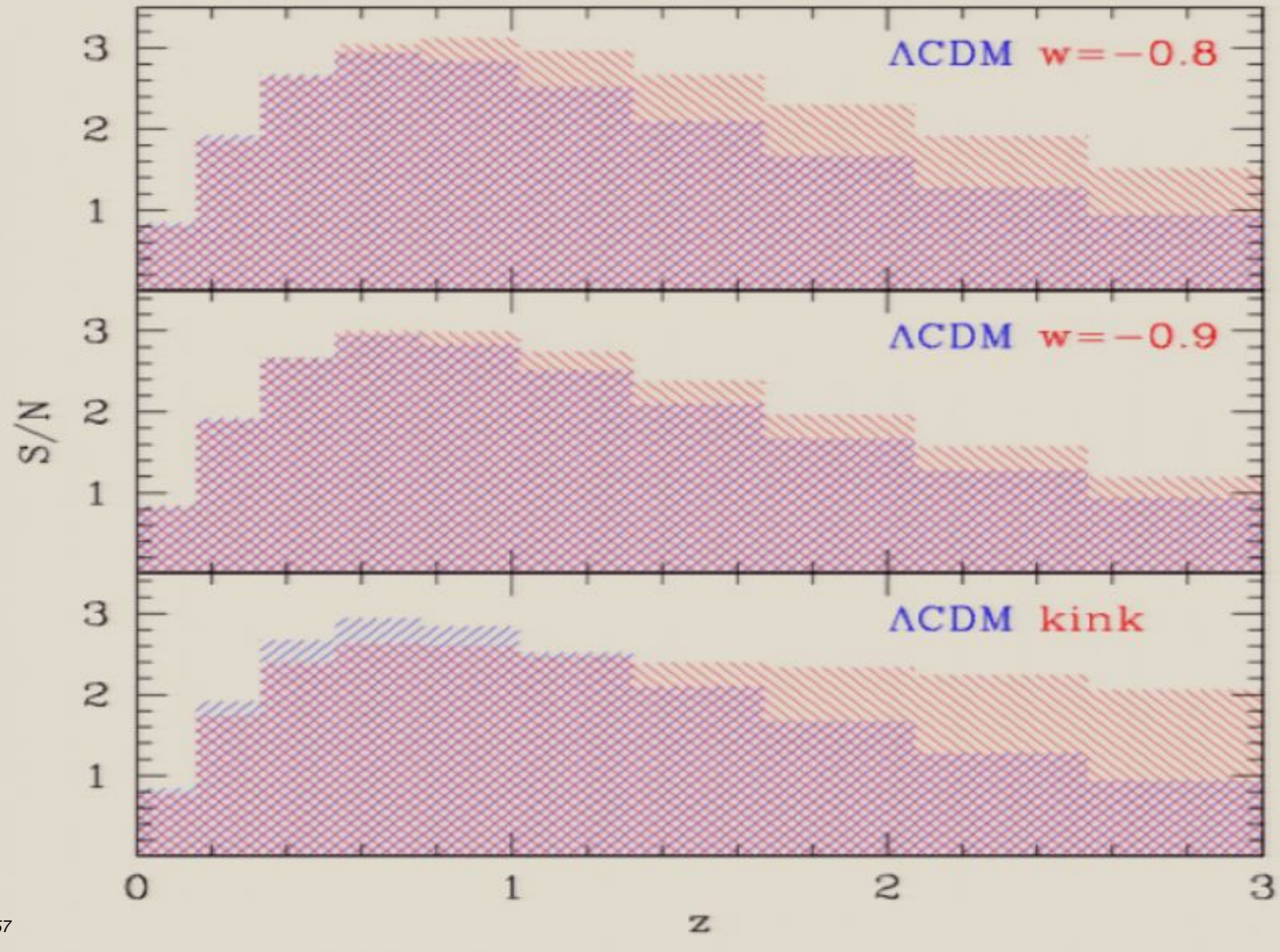

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Principal Components

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$$w(z) = \sum_{i=1}^{N} w_i b_i(z)$$

$$z_1 < \ldots < z_{i-1} < z_i < \ldots < z_N; \quad b_i \approx \begin{cases} 1, & z_{i-1} < z < z_i \\ 0, & z_{i-1} > z > z_i \end{cases}$$

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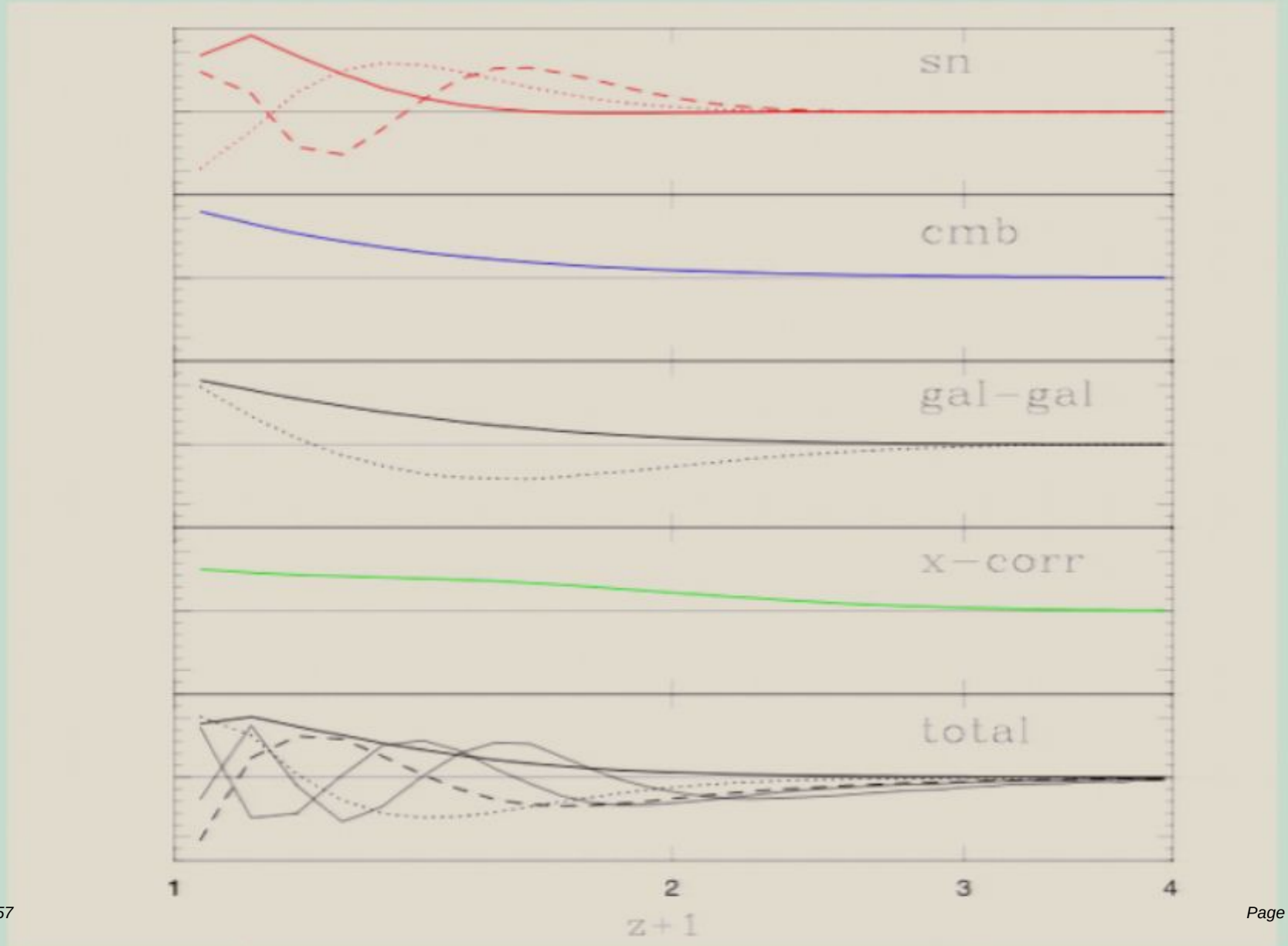
Huterer & Starkman, PRL 2003

Best determined modes



L. Crittenden and L. Pogosian, astro-ph/0510293

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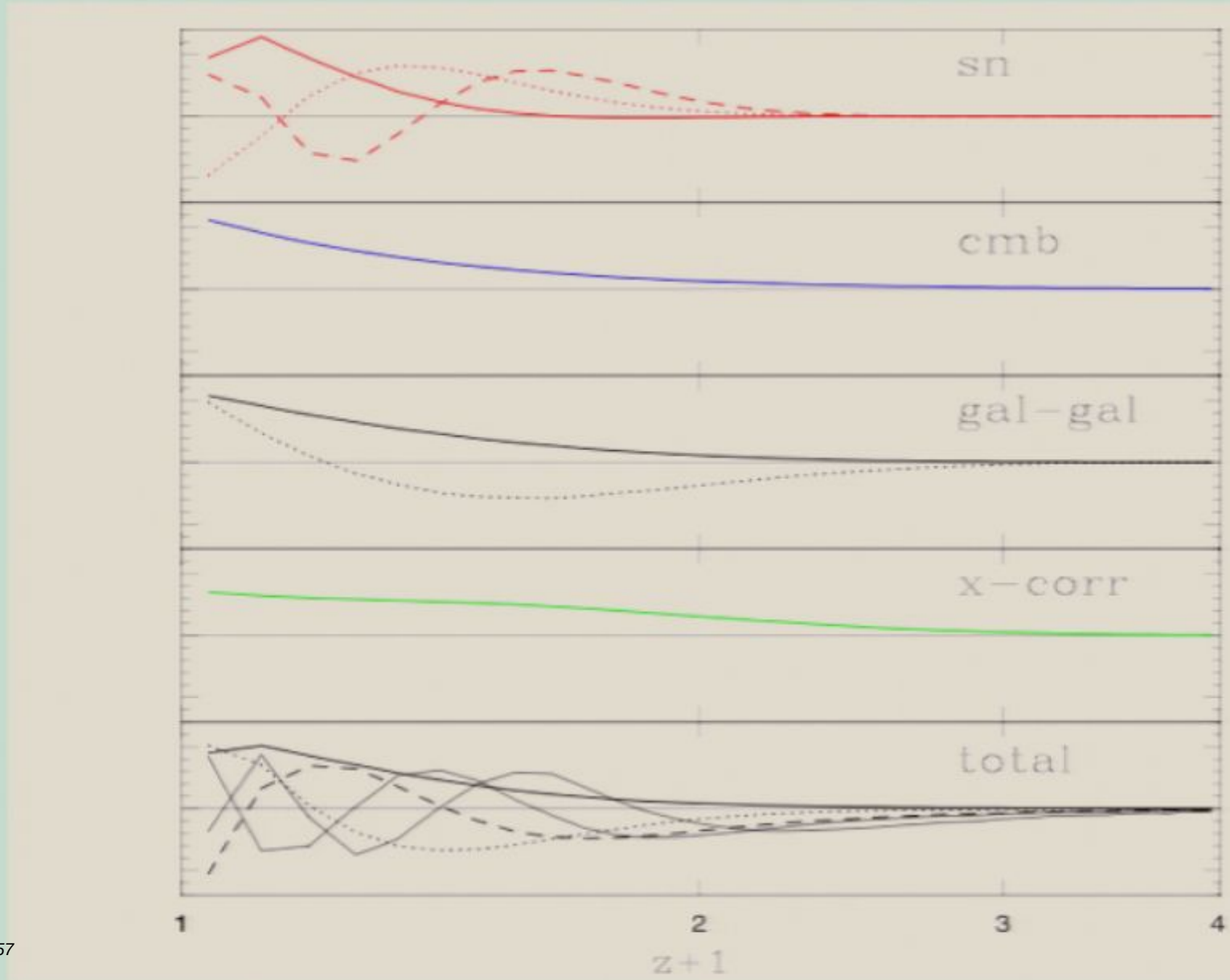
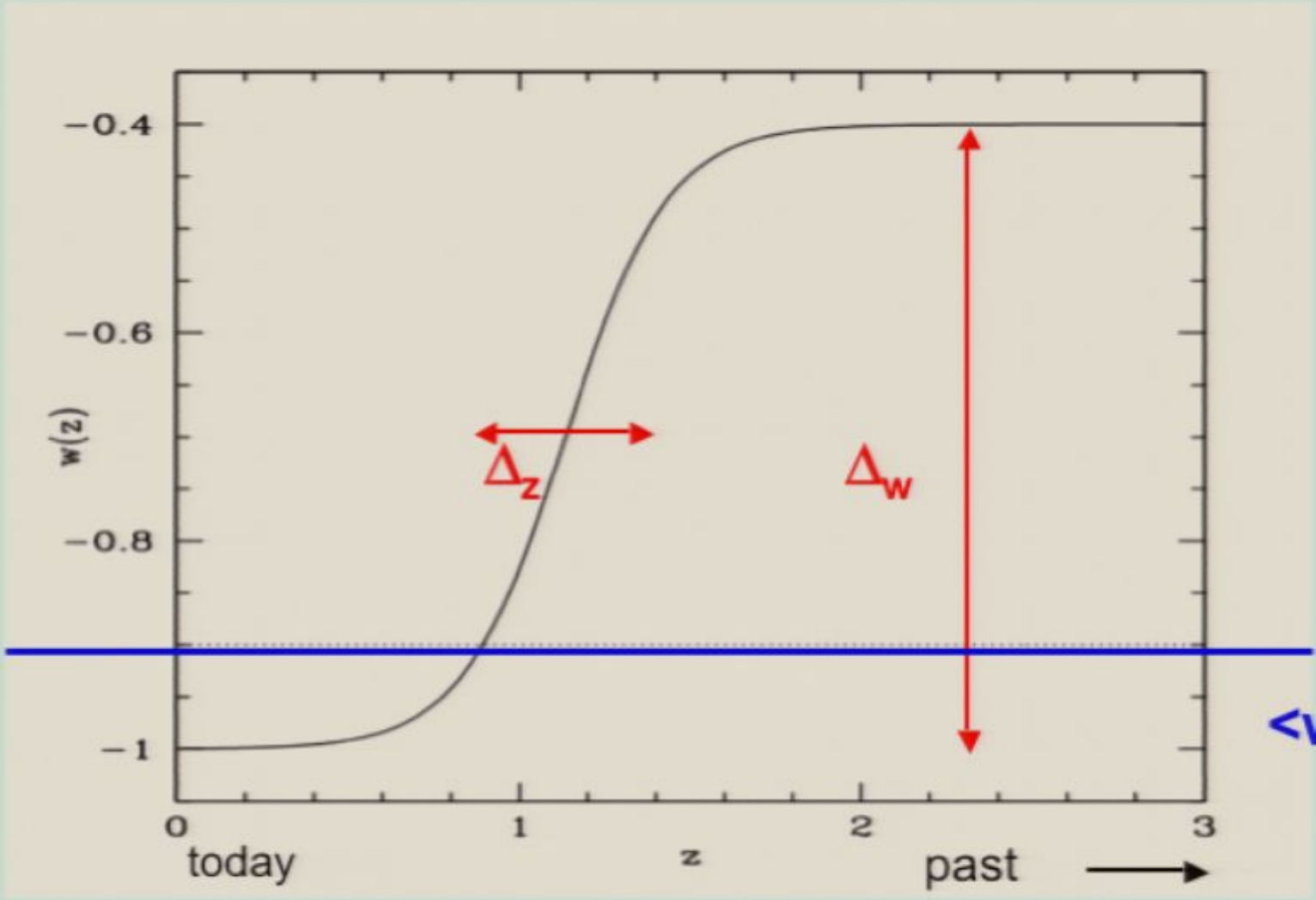


R. Crittenden and L. Pogosian, astro-ph/0510293

The kink



$$\langle w \rangle \equiv \frac{\int_{a_{ls}}^{1} da\, \Omega_Q(a) w_Q(a)}{\int_{a_{ls}}^{1} da\, \Omega_Q(a)}$$

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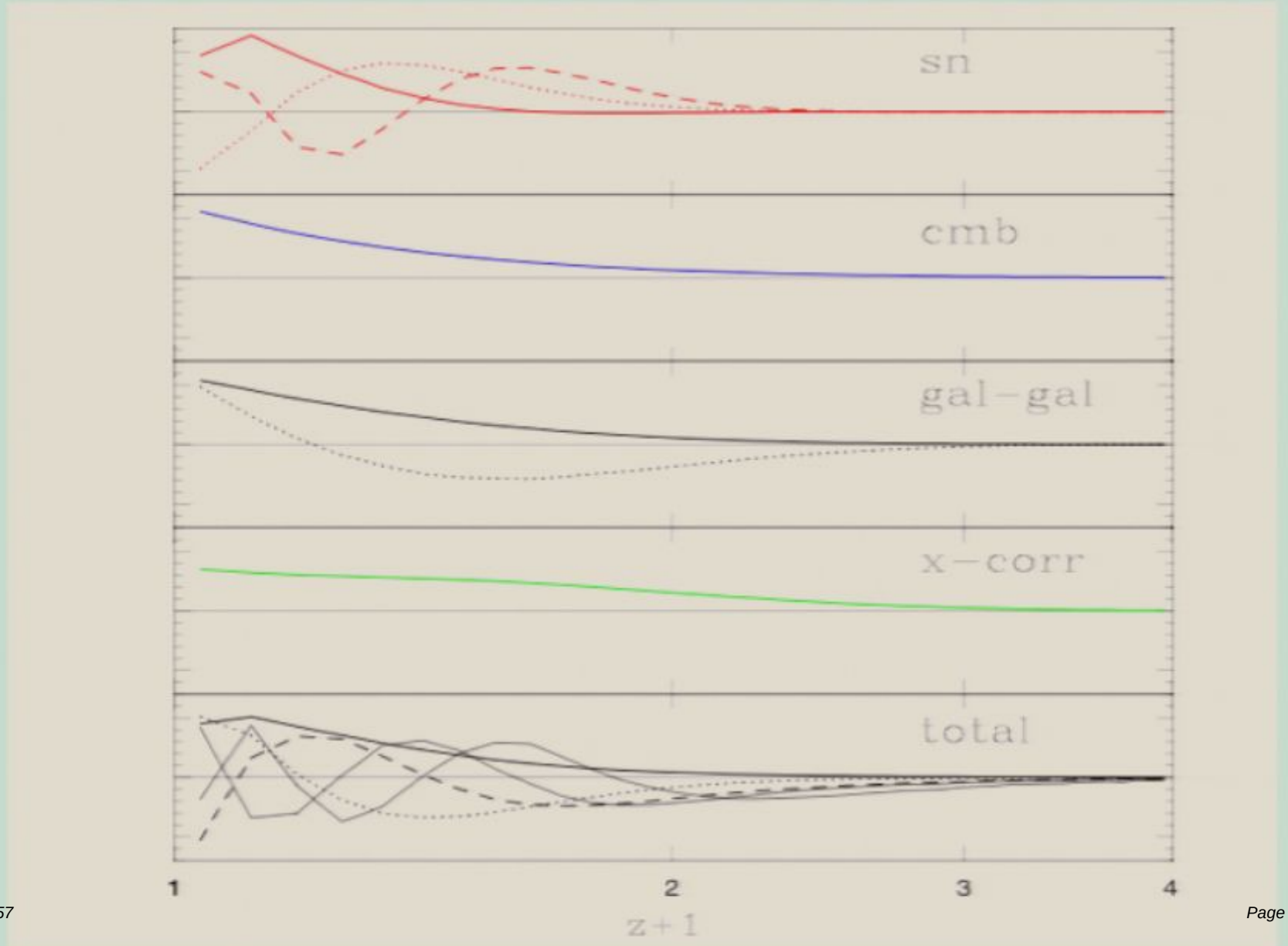

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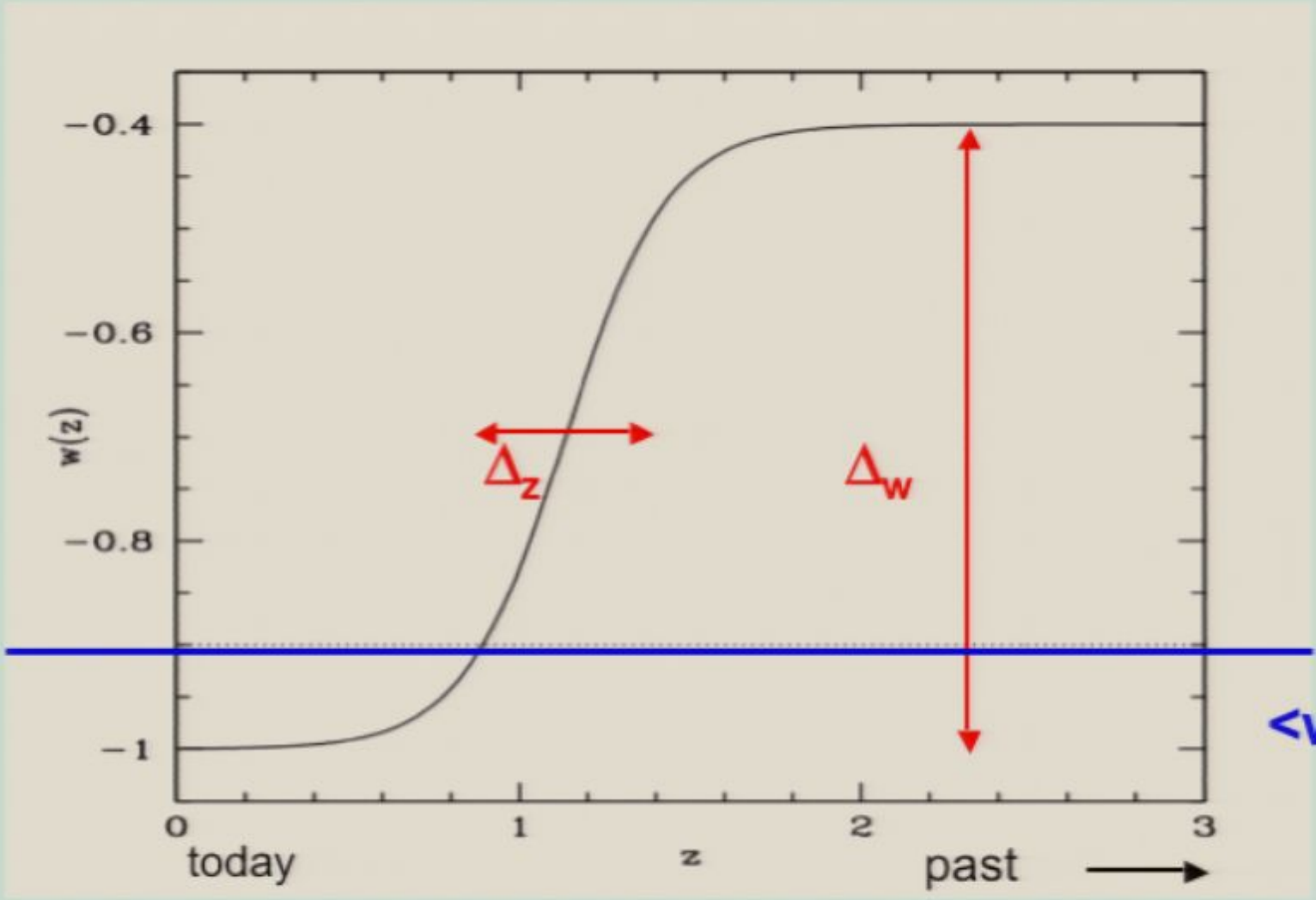

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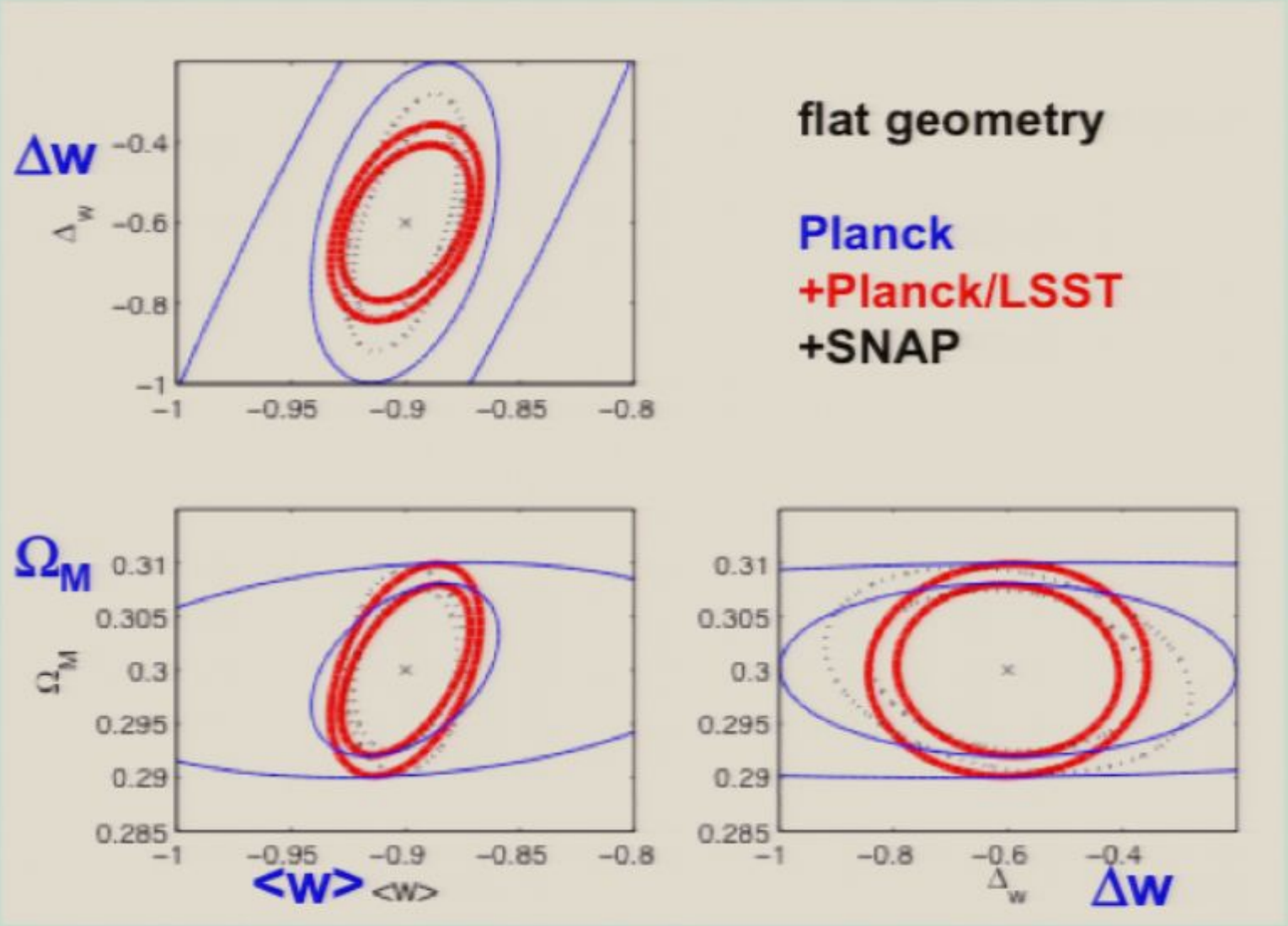
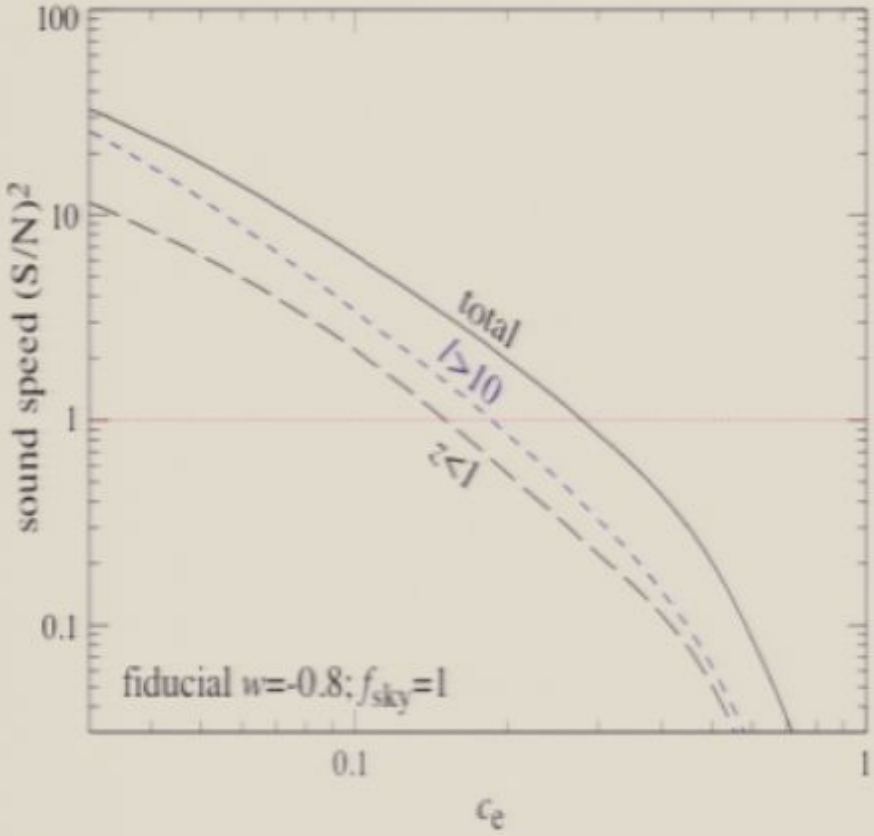
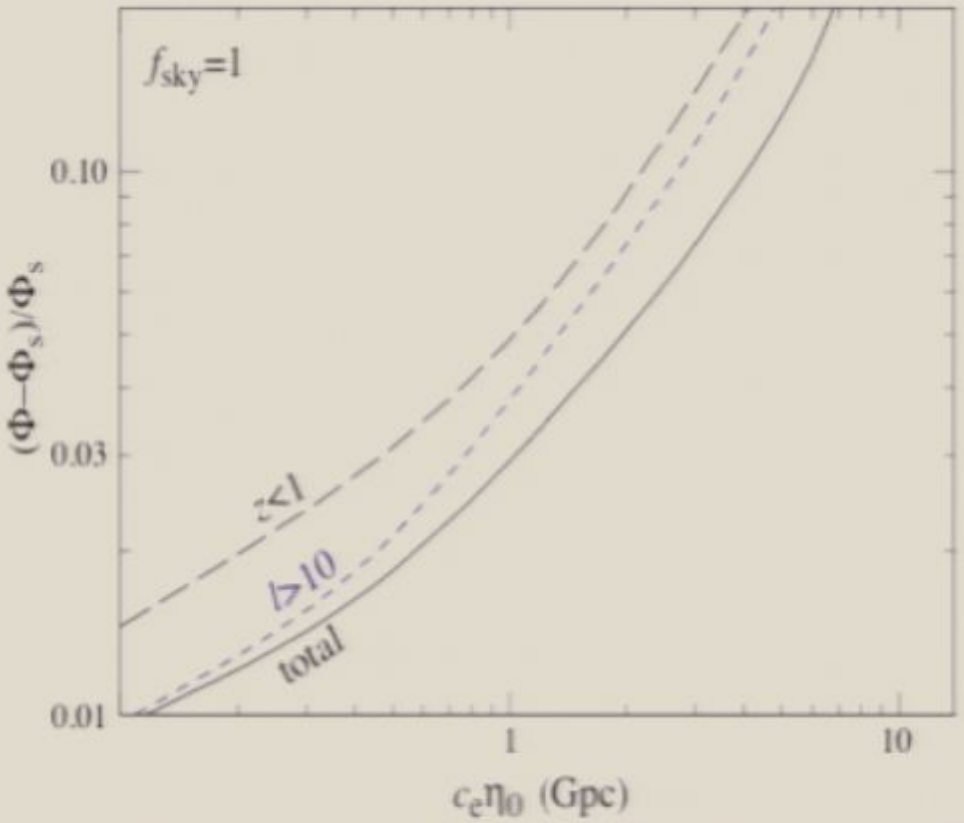


Pogosian, Corasaniti, Stephan-Otto, Crittenden, Nichol, astro-ph/0506396

Dark energy clustering

Bean & Dore, astro-ph/0307100
Hu & Scranton, astro-ph/0408456
Corasaniti, Giannantonio, Melchiorri, astro-ph/0504115





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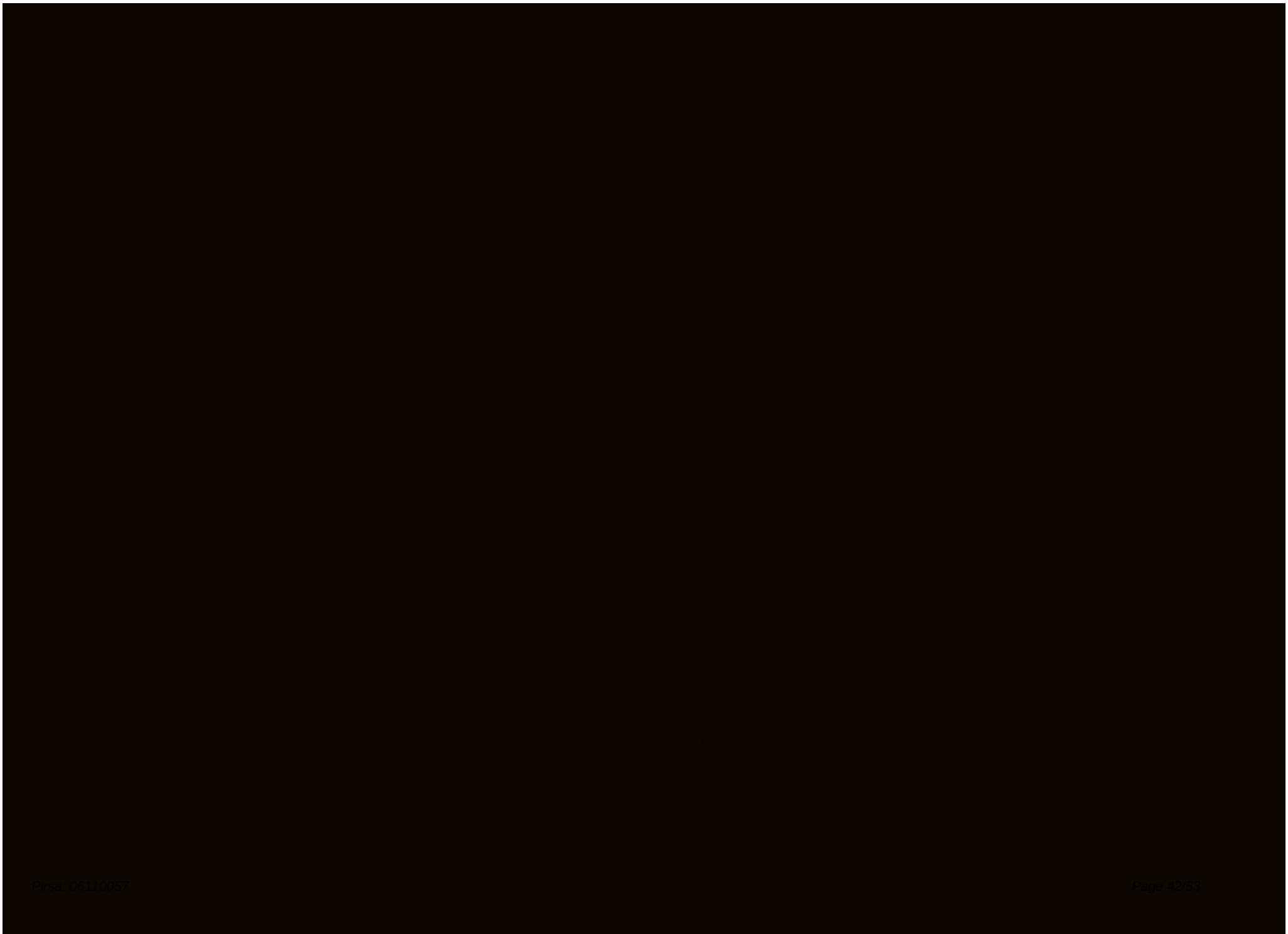

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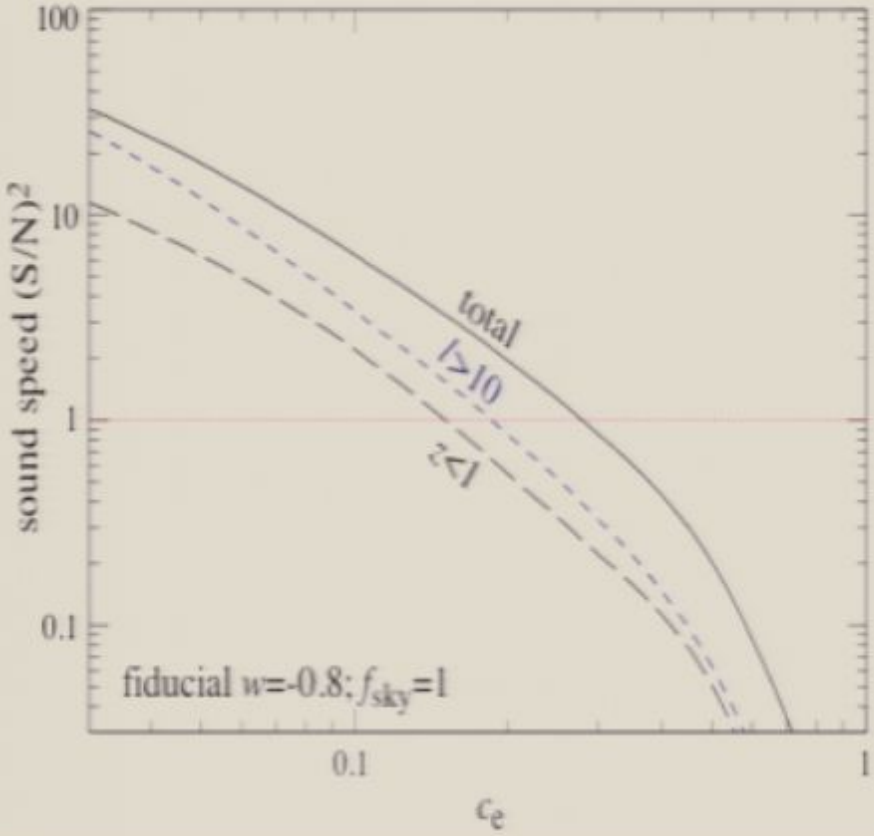

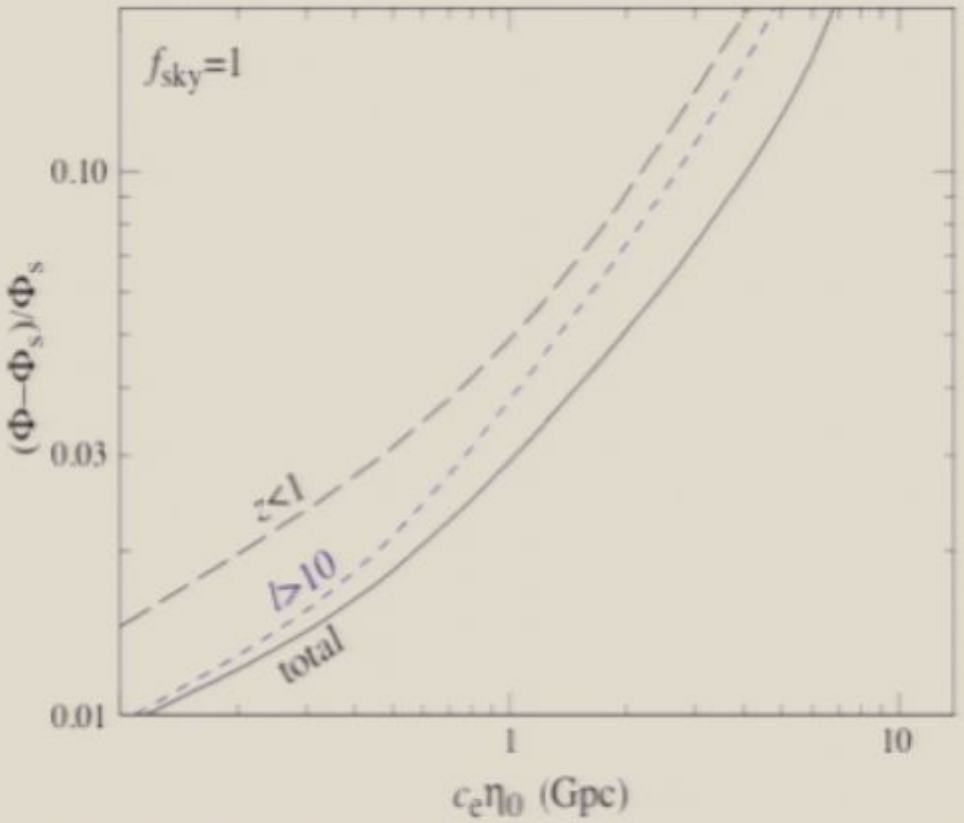

from **Hu & Scranton,** astro-ph/0408456

Modified gravity

The oDGP model

$w_Q(a) = -1/3 \rightarrow -1/2 \rightarrow -0.85$

$\Omega_k=0.036 \quad \Omega_m=0.18 \quad h=0.8$

Song, Sawicki, Hu, astro-ph/0606286

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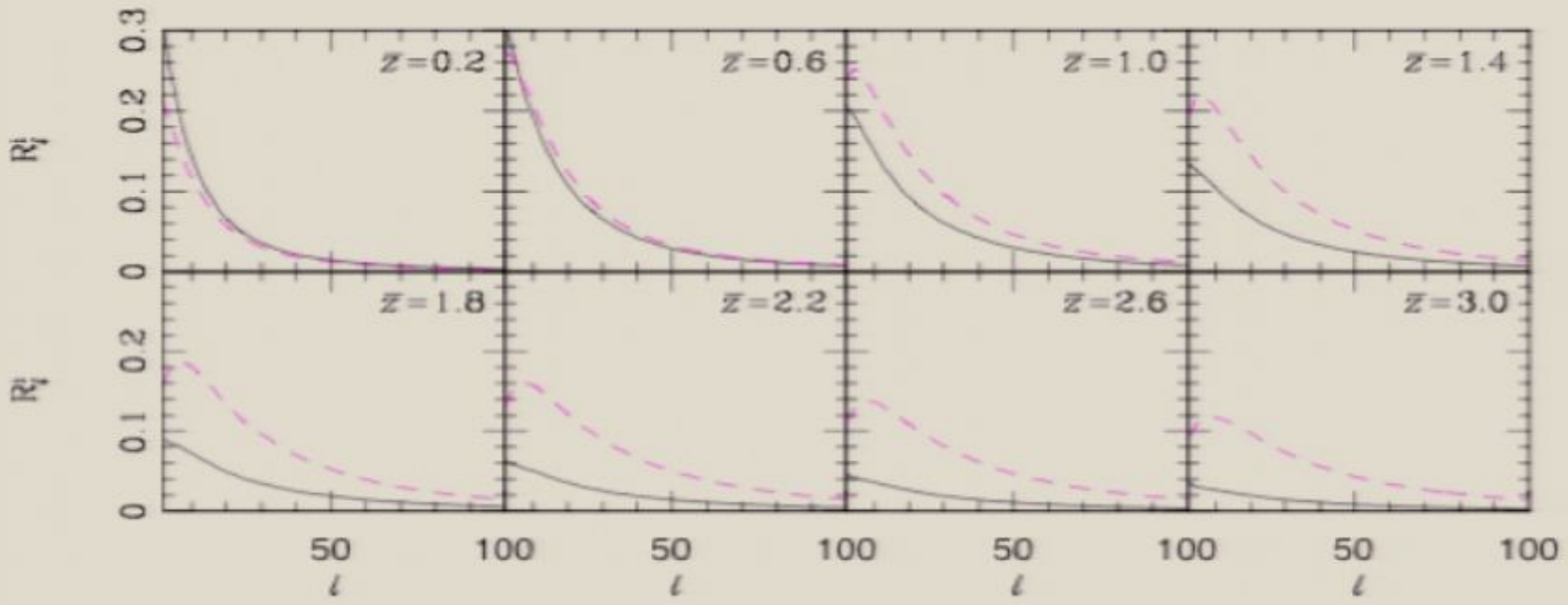

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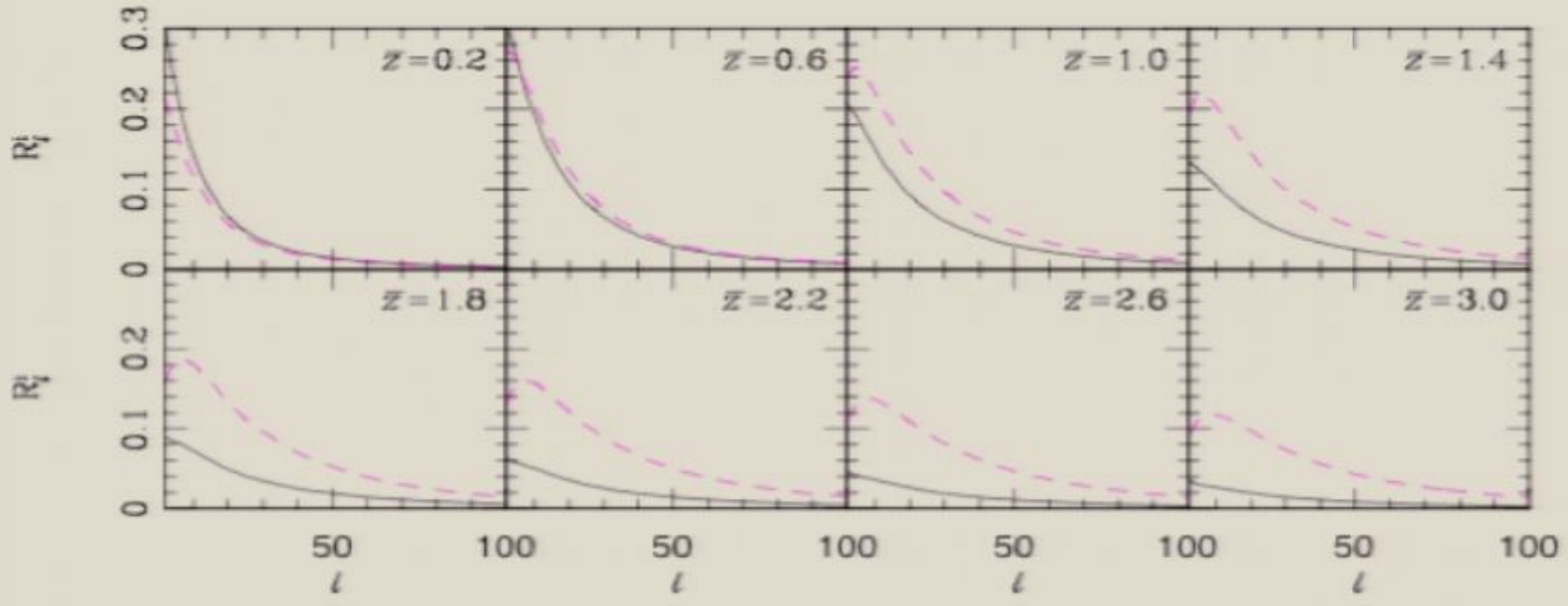

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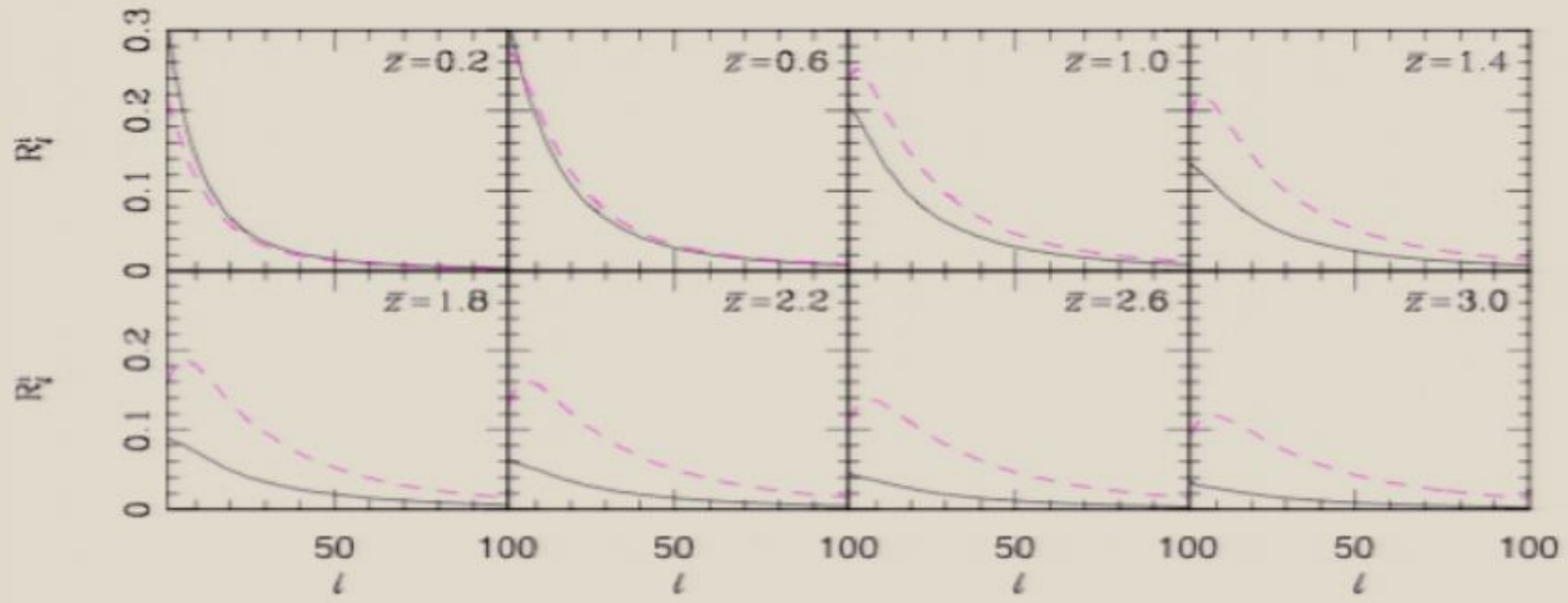

Song, Sawicki, Hu, astro-ph/0606286

Summary

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Future ISW measurements will provide

- high-z constraints on $w_{DE}(z)$
- test of alternatives to GR
- probe of Dark Energy perturbations
- ???