Revising the Halo-Fit Model for WMAP Cosmological Models

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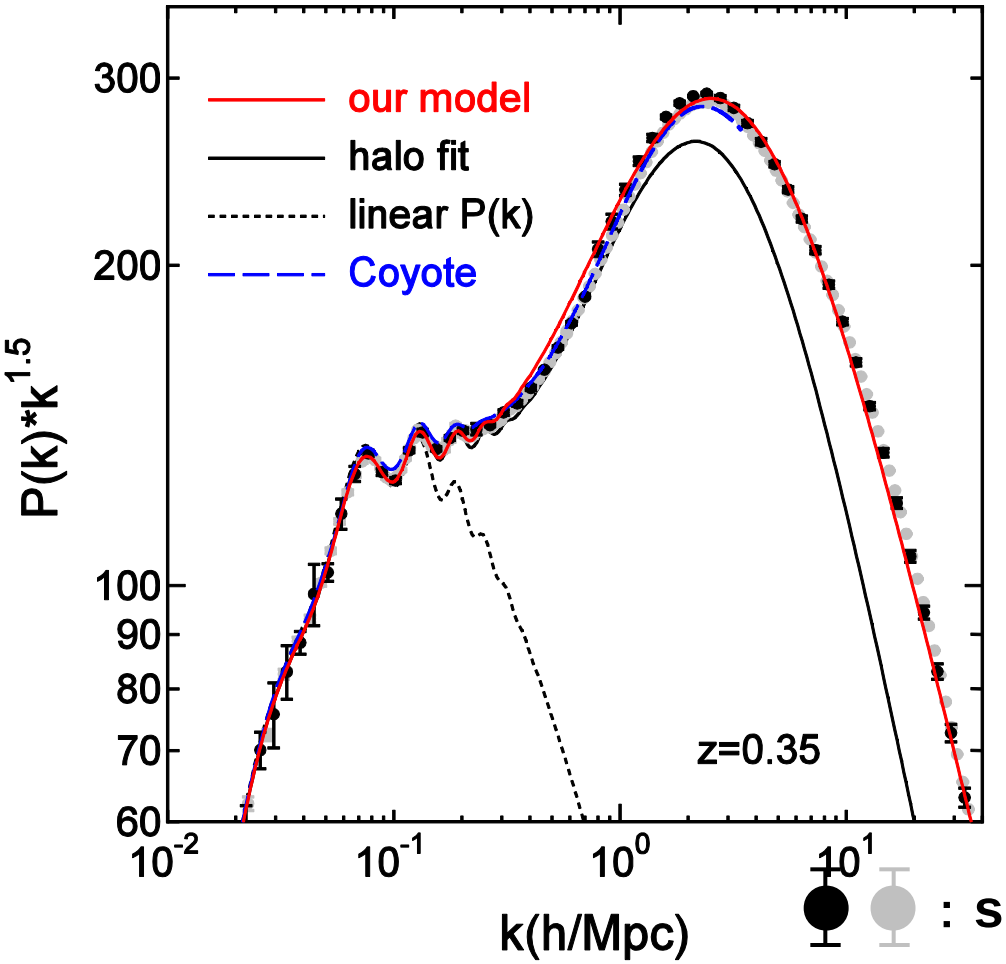
Abstract

Fitting function of non-linear matter power spectrum

Halo-fit model
～30% discrepancy

our model
<6% agreement



: simulation results

● Introduction

A power spectrum P(k) of dark matter density fluctuation is a basic quantity in Cosmology.

(galaxy distribution, weak lensing, …)

We usually calculate an accurate P(k) using

- **Perturbation Theories** — **in (quasi-)linear regime**
- **Cosmological N-body simulations**
- **Fitting Functions**

} **in non-linear regime**

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● Introduction

Weak lensing by large-scale structure（cosmic shear）is an powerful tool in observational Cosmology.

The WL signal is measured by large surveys such as CFHTLS, COSMOS, SDSS,

（Fu+ 2008; Schrabback+ 2010; Lin+ 2011; Huff+ 2011）

and will be measured by larger surveys such as HSC, DES, LSST in near future.

We need the P(k) within a few percent accuracy at k<10h/Mpc for DES and LSST to reduce a systematic error smaller than a statistical error.

（Huterer & Takada 2005; Eifler 2011）

● previous fitting formula for non-linear P(k)

The fitting function based on N-body simulations

Peacock & Dodds 1996

based on Hamilton+ 1991

Smith+ 2003

based on Halo model（Seljak 2000）

Heitmann+ 2009,2010（Coyote Universe）

They provide an emulator to calculate non-linear P(k)

It can be used only for k<3h/Mpc & 0<z<1

● Halo-fit model（Smith+ 2003）

$$P(k) = P_{1h}(k) + P_{2h}(k)$$

one halo term　two halo term

the fitting function to fit their simulation results based on the halo model

30 fitting parameters

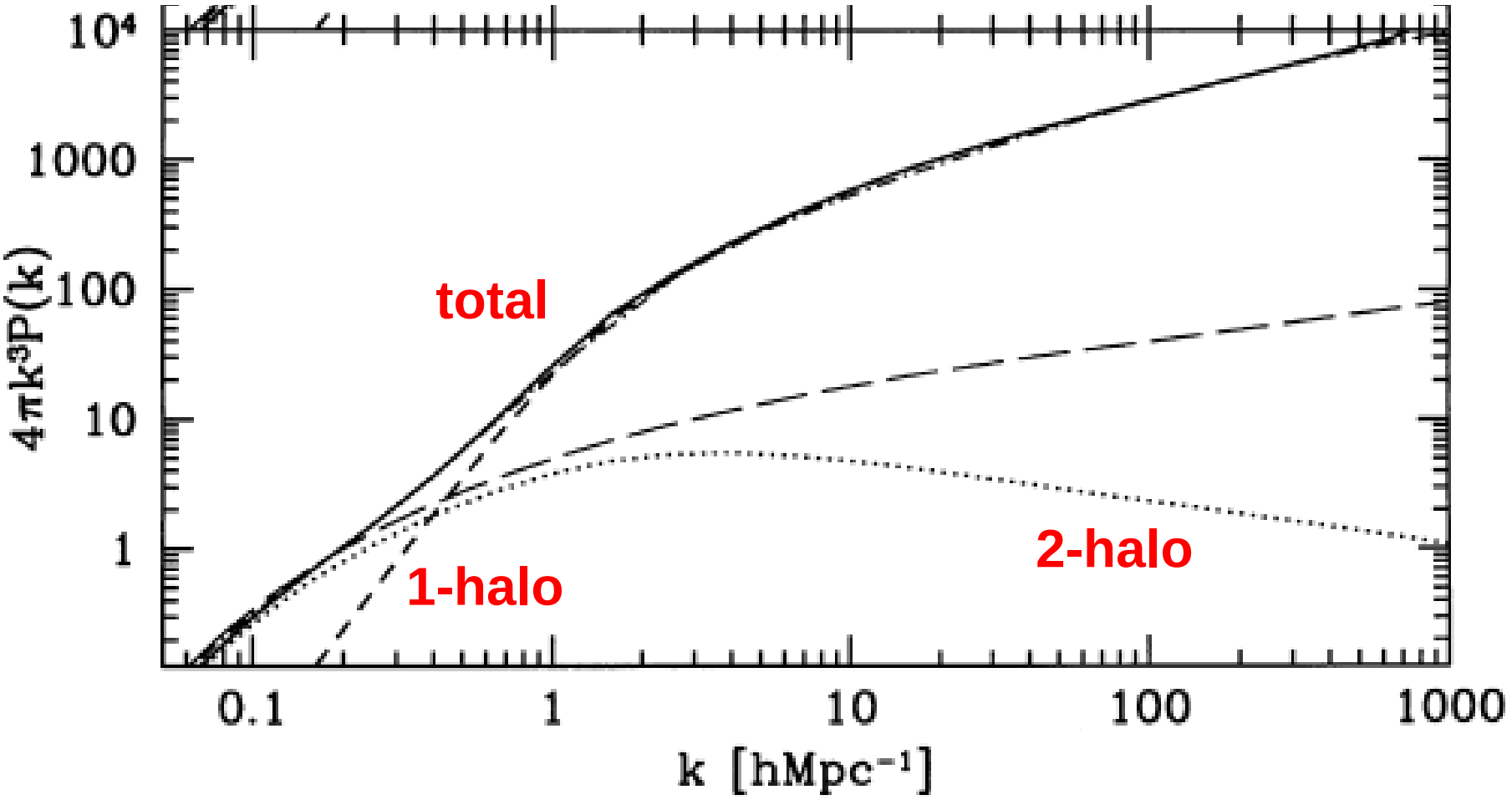
Problems _

The halo-fit model underestimates the power spectrum at small scales k>0.1h/Mpc by a few ten percents

（e.g. Vale & White 2004; Sato+ 2009; Heitmann+ 2010; Peacock）

Because their simulation is not high resolution at present

● Halo model（Seljak 2000）



In this work

Re-calculating the 30 fitting parameters in the halo-fit using our up-to-date simulations.

Our simulations：

1024^3 particels

box size L=320,800Mpc/h & 2Gpc/h

Nishimichi-kun's simulations：

2048^3 particles

box size L=4,2,1Gpc/h & 500Mpc/h

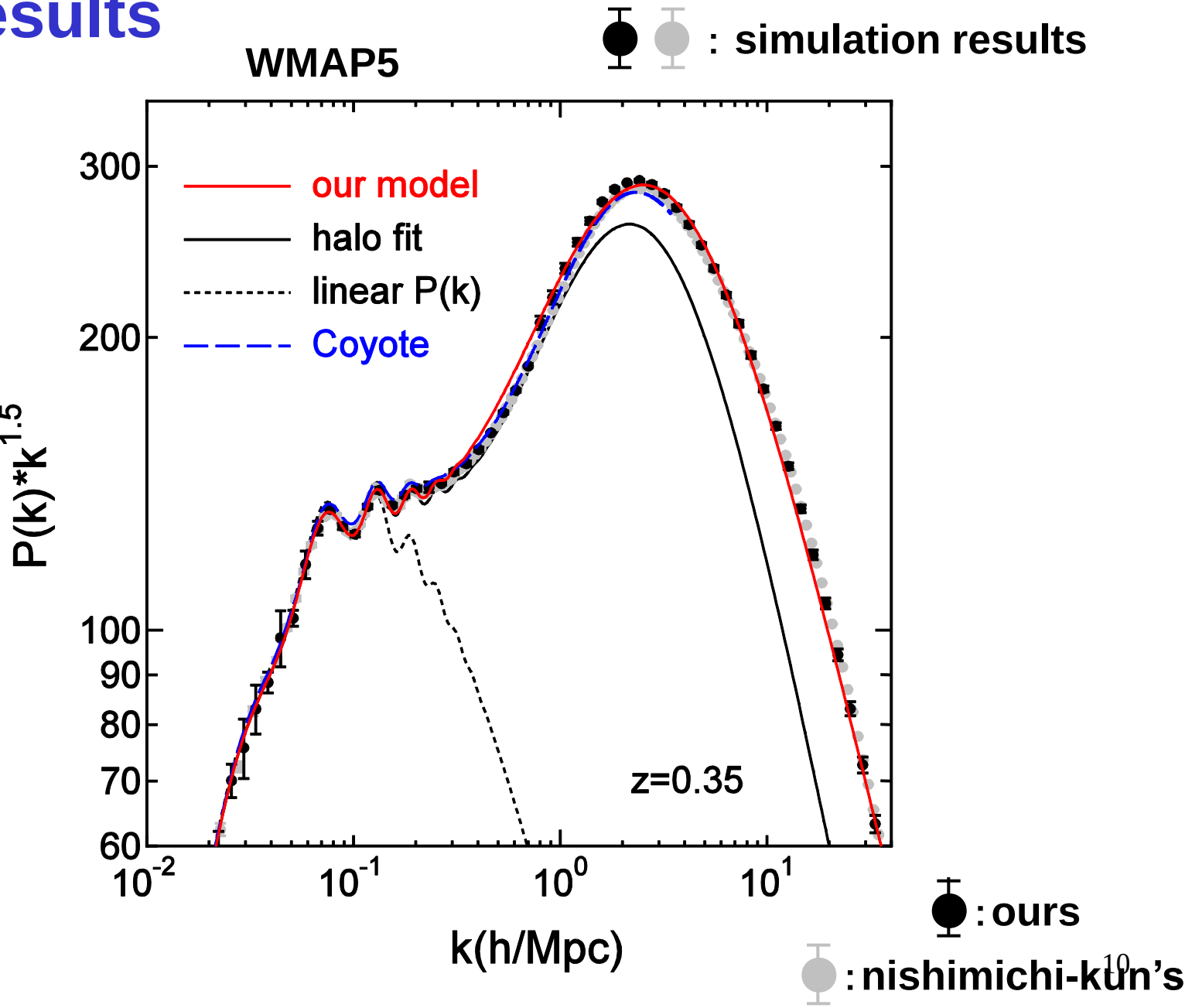
（Valageas & Nishimichi 2011）

code: Gadget2

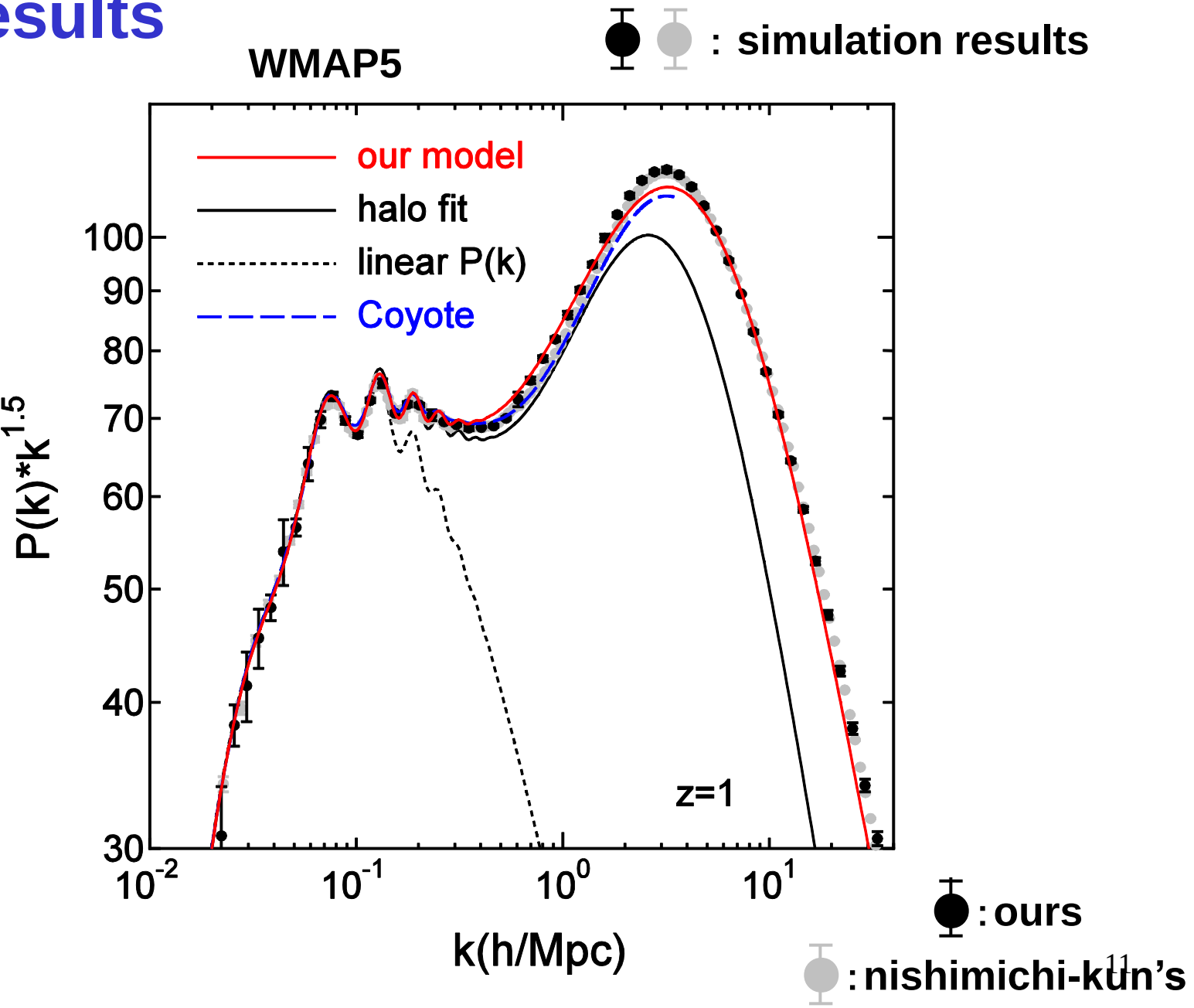
redshifts z=0-5　　wave number k<30h/Mpc

cosmological models : WMAP1,3,5 & 7yr

Results


WMAP5
: simulation results
our model
halo fit
linear P(k)
Coyote
z=0.35
P(k)*k^1.5
k(h/Mpc)
300
200
100
90
80
70
60
10^-2
10^-1
10^0
10^1
: ours
: nishimichi-kun's

Results


WMAP5
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z=1
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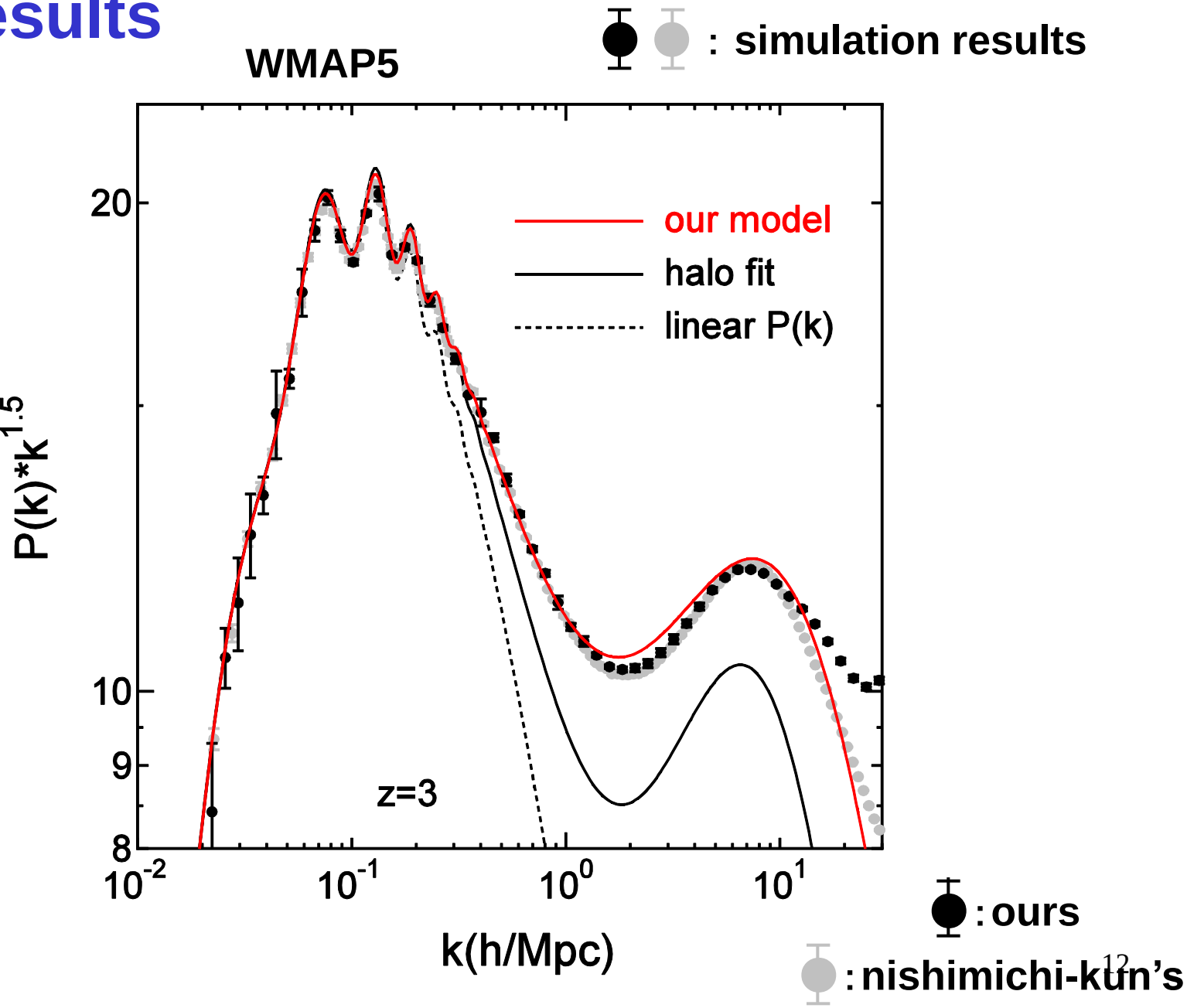
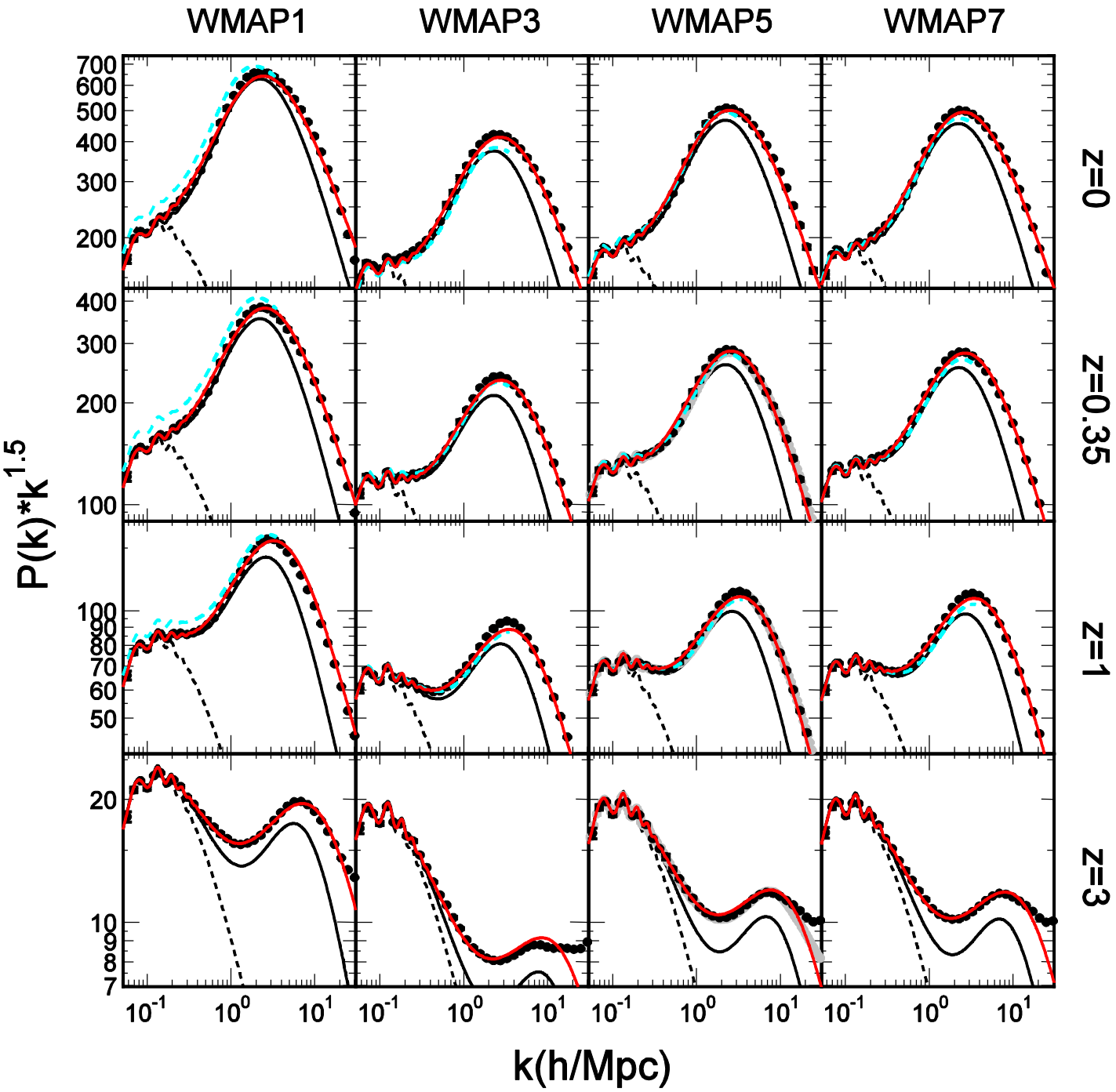
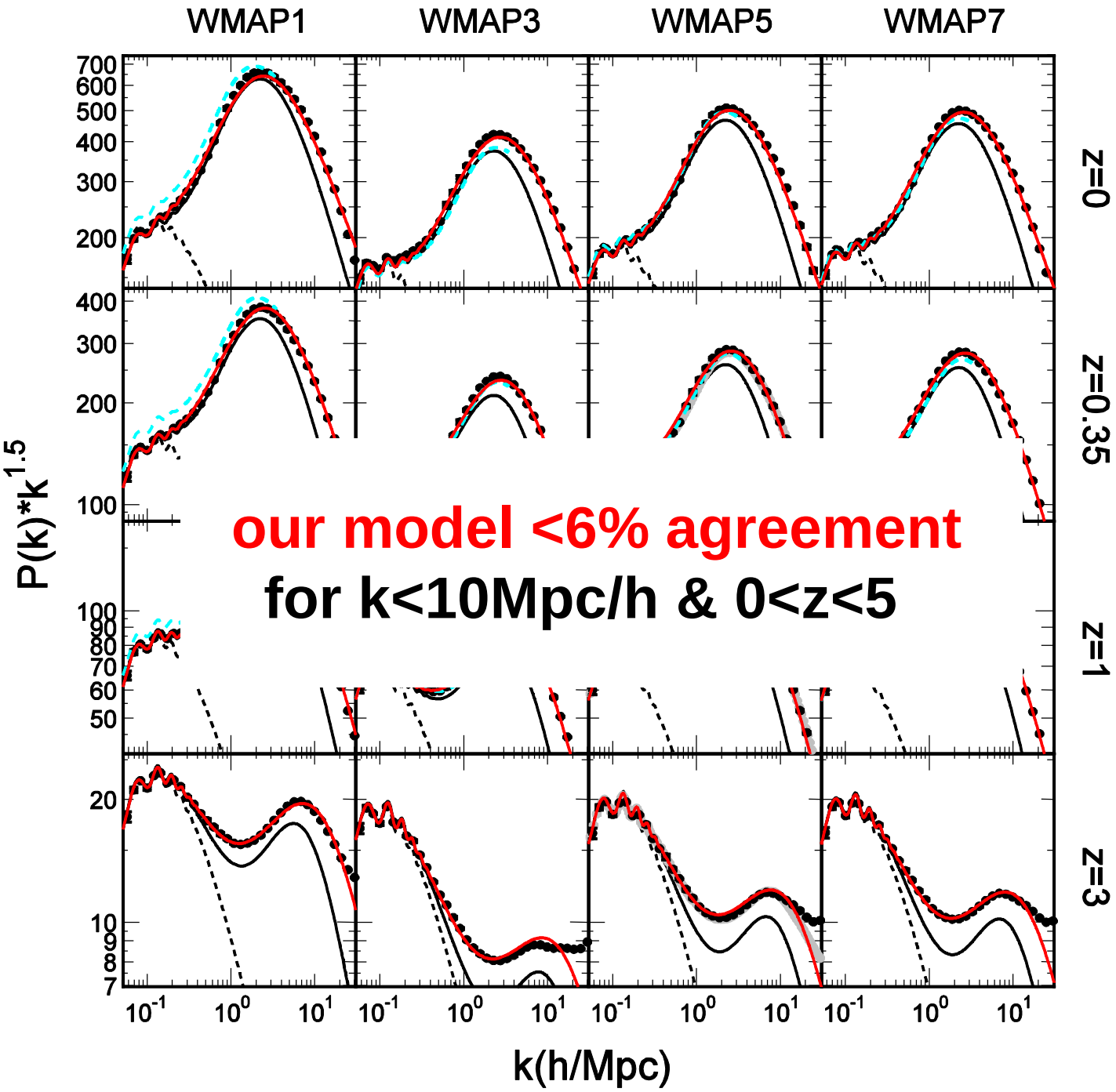

WMAP5
: simulation results
our model
halo fit
linear P(k)
z=3
P(k)*k^1.5
k(h/Mpc)
20
10
9
8
10^-2
10^-1
10^0
10^1
: ours
: nishimichi-kun's


WMAP1
WMAP3
WMAP5
WMAP7
z=0
z=0.35
z=1
z=3
P(k)*k^1.5
k(h/Mpc)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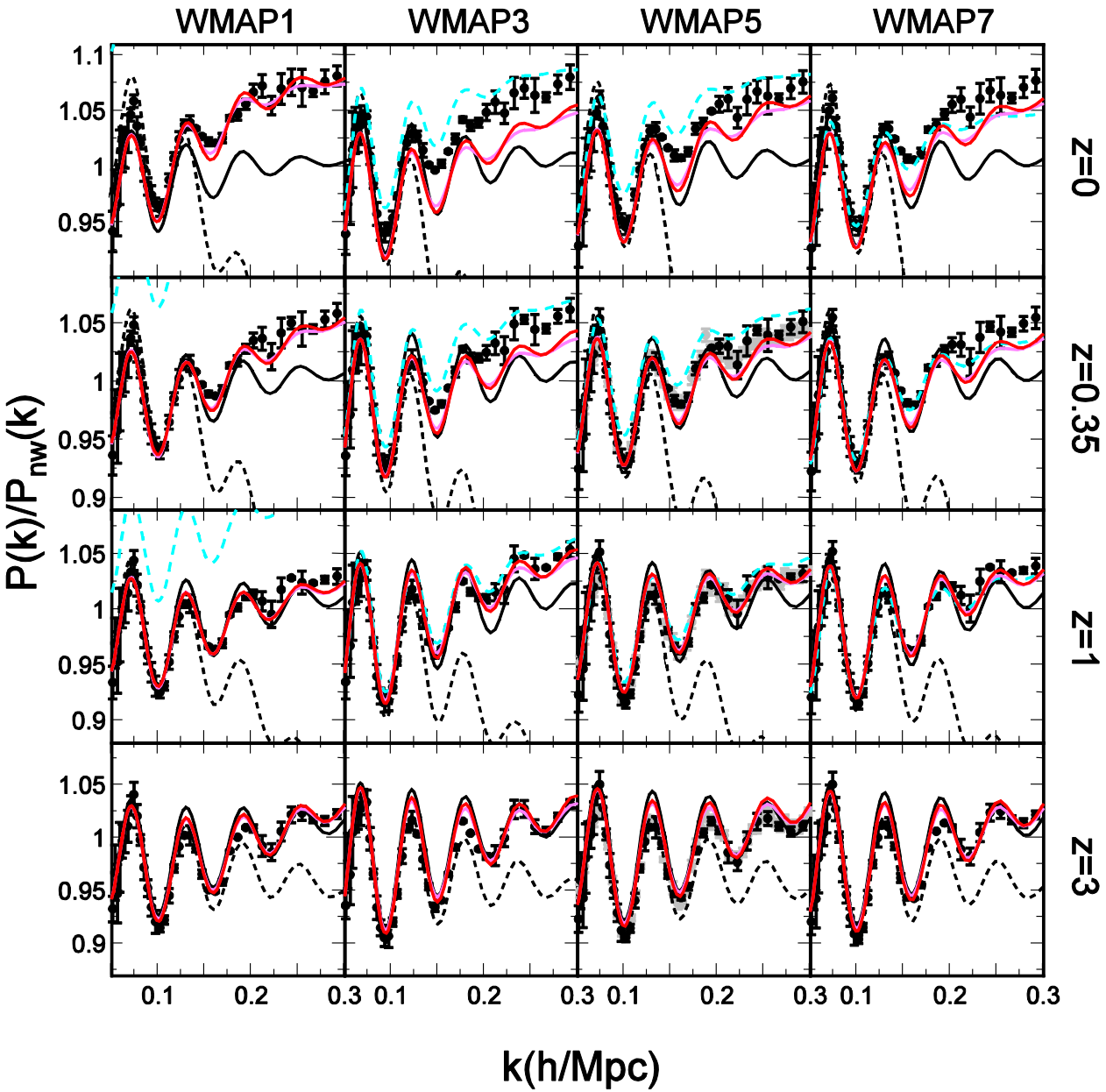
P(k)*k^1.5
k(h/Mpc)
our model <6% agreement
for k<10Mpc/h & 0<z<5

P(k) at BAO scale



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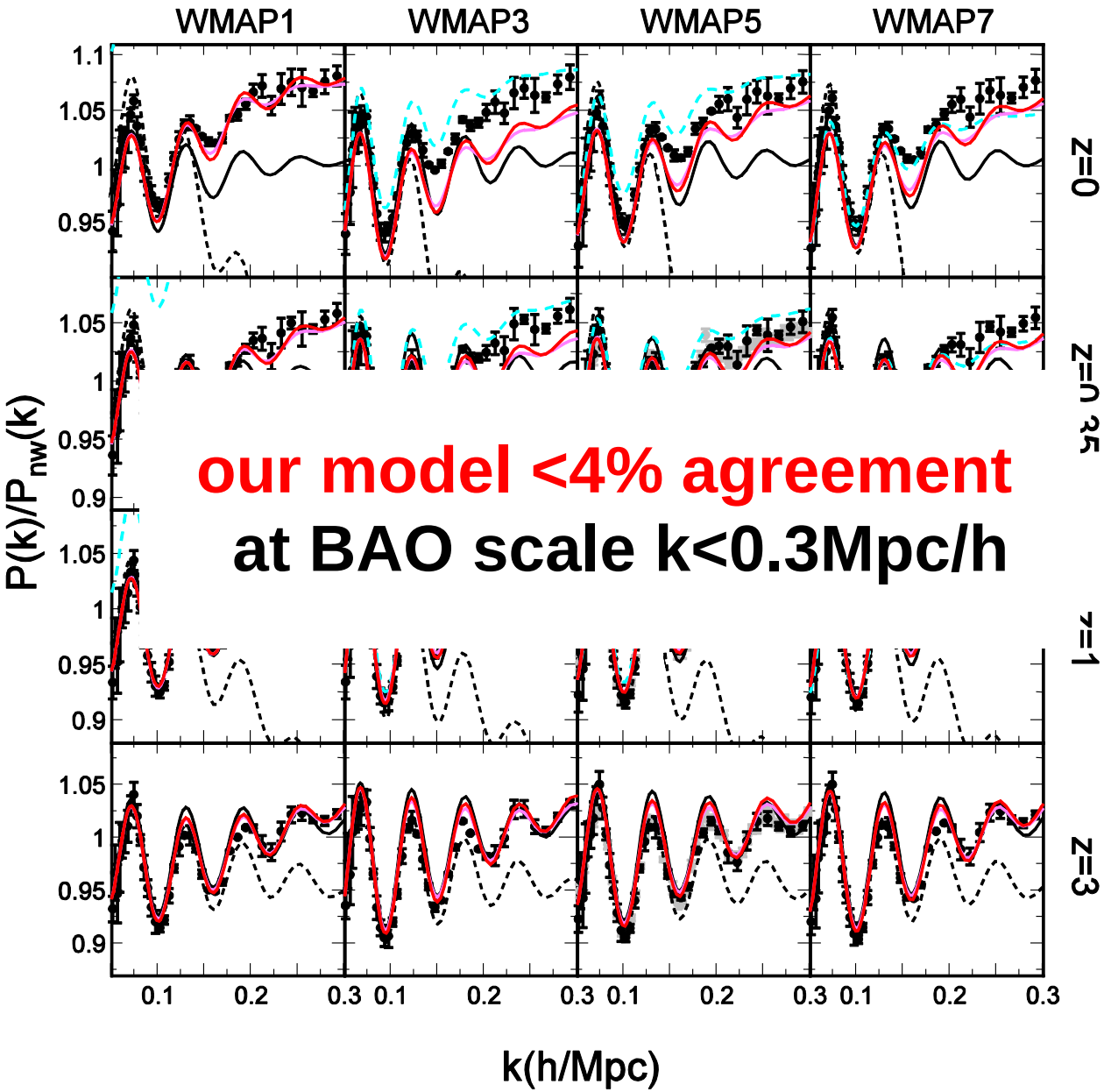
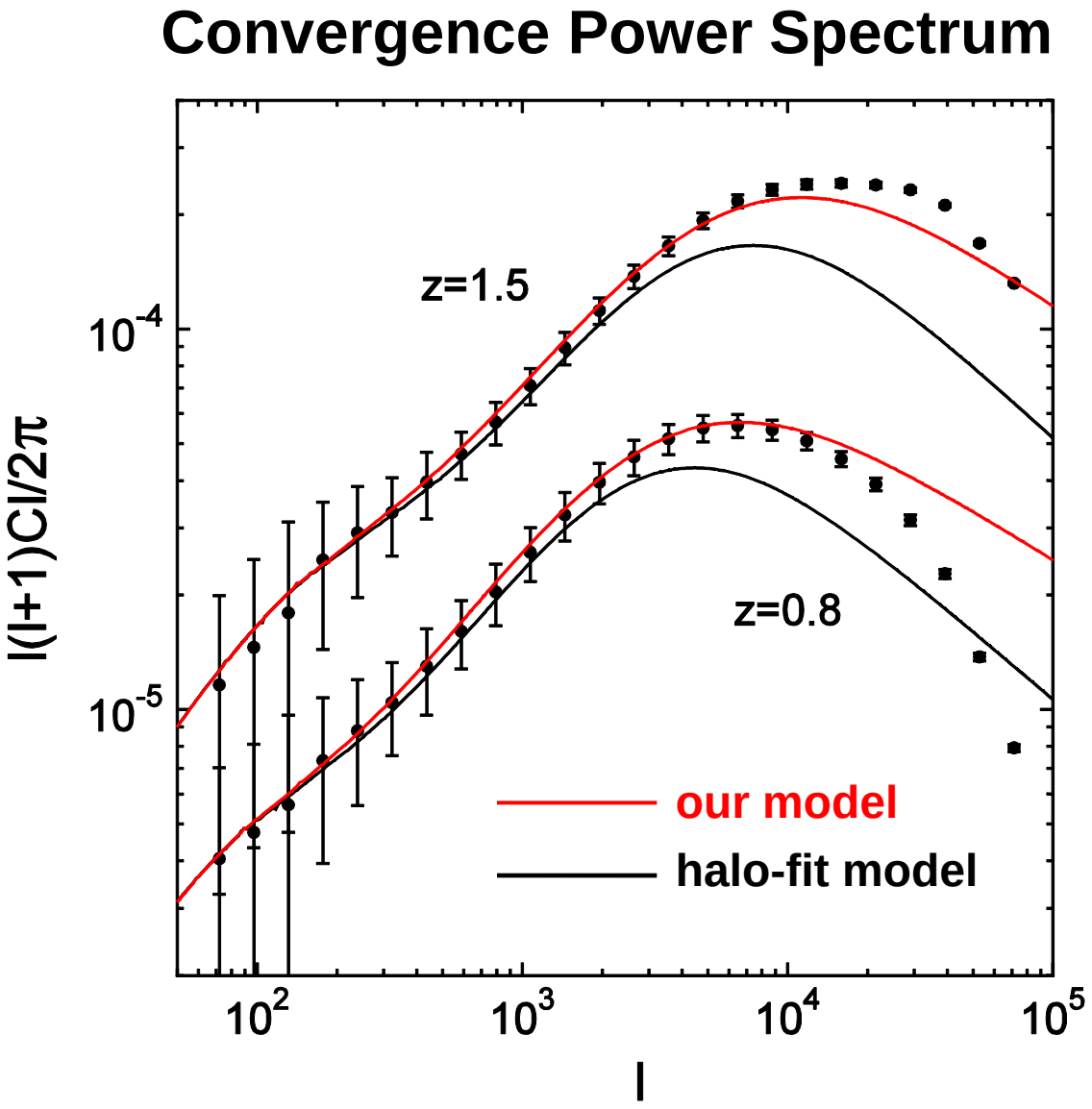
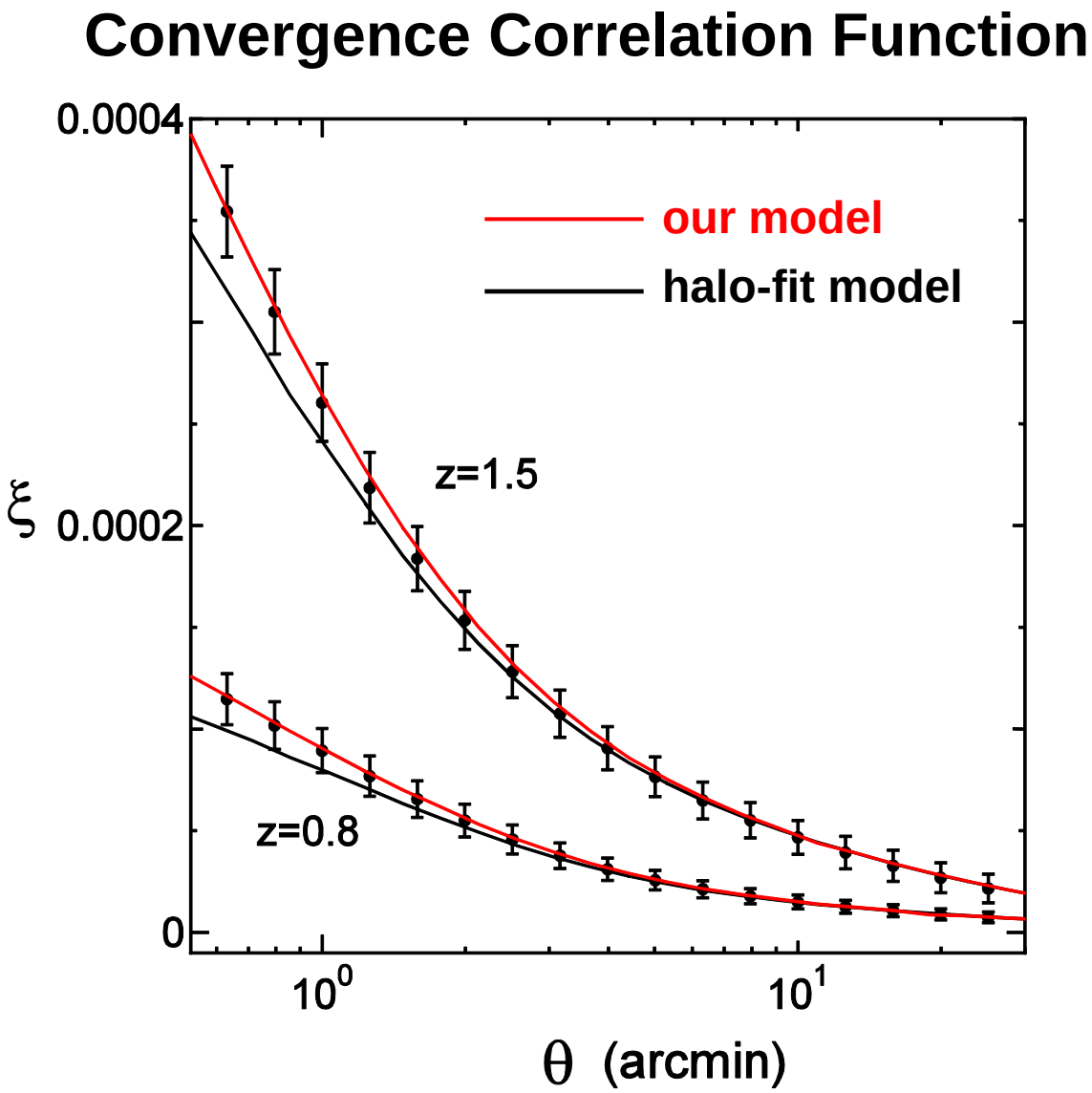


Weak lensing



simulation data from Sato+（2009,2011）

Weak lensing



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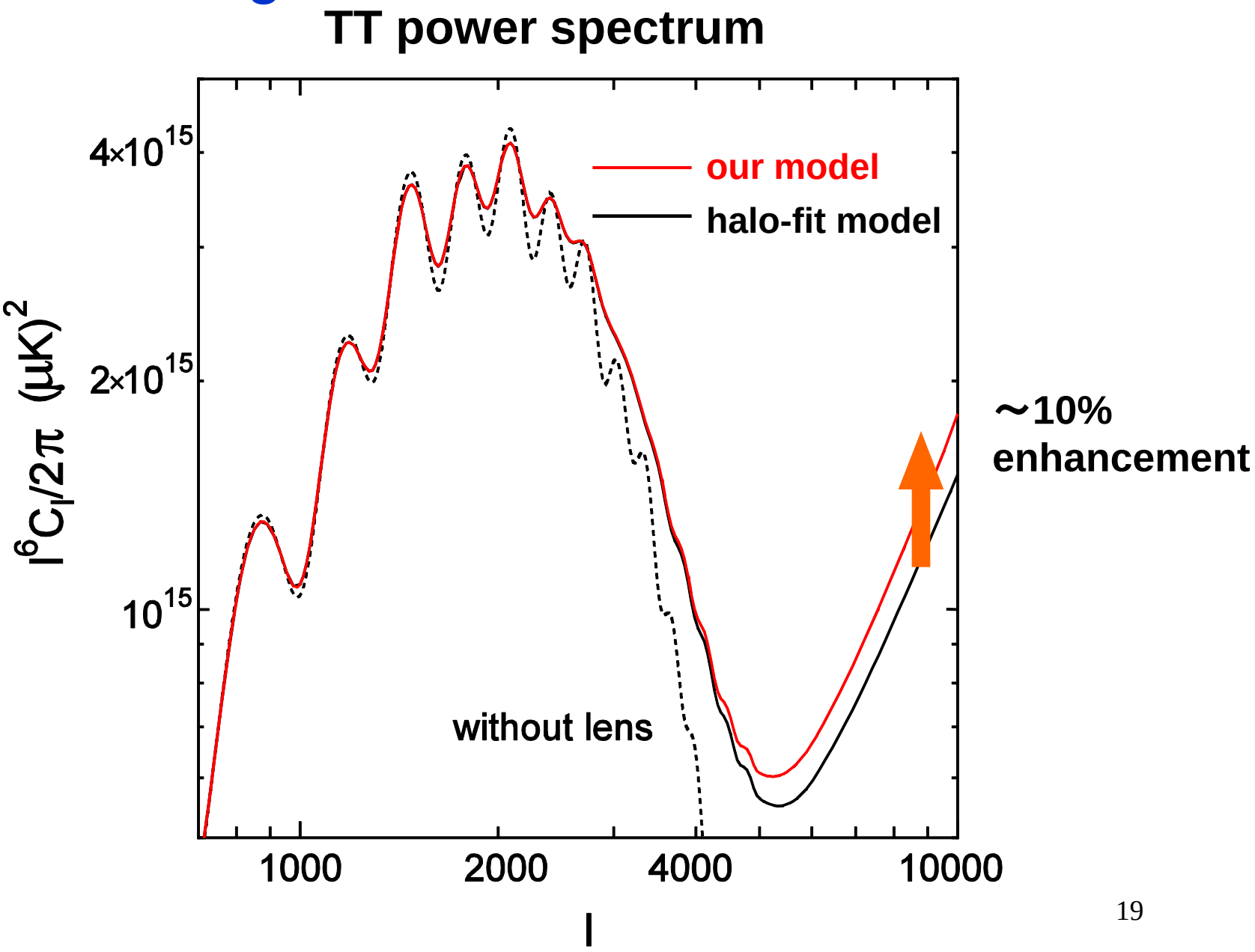
CMB lensing


TT power spectrum
$l^6C_l/2\pi\ (\mu K)^2$
4×10^{15}
2×10^{15}
10^{15}
our model
halo-fit model
without lens
~10%
enhancement
1000
2000
4000
10000
l

Conclusions

The halo-fit underestimates the non-linear P(k) at small scales k>0.1h/Mpc by a few ten percents

Our revised model agrees within 6 % for k<10h/Mpc

We are now taking into account the dark energy

The paper will be put on the arXiv soon.

TABLE 1

Models	Ω_b	Ω_m	Ω_Λ	h	σ_8	n_s
WMAP1	0.044	0.29	0.71	0.72	0.9	0.99
WMAP3	0.041	0.238	0.762	0.732	0.76	0.958
WMAP5	0.046035	0.279	0.721	0.701	0.817	0.96
WMAP7	0.046	0.272	0.728	0.7	0.81	0.97

NOTE. — WMAP cosmological parameters.