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Signatures of the Baryon acoustic oscillations on the convergence power spectrum of weak lensing by large scale structure

Tong-Jie Zhang [a,b,*], Qiang Yuan [c], Tiang Lan [a]

[a] Department of Astronomy, Beijing Normal University, No. 19 Xinjiekouwai Street, Beijing 100875, PR China
[b] Kavli Institute for Theoretical Physics China, Institute of Theoretical Physics, Chinese Academy of Sciences (KITPC/ITP-CAS), P.O. Box 2735, Beijing 100080, PR China
[c] Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, P.O. Box 918-3, Beijing 100049, PR China

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ABSTRACT

We employ an analytical approach to investigate the signatures of Baryon acoustic oscillations (BAOs) on the convergence power spectrum of weak lensing by large scale structure. It is shown that the BAOs wiggles can be found in both of the linear and nonlinear convergence power spectra of weak lensing at about $40 \leqslant l \leqslant 600$, but they are weaker than that of matter power spectrum. Although the statistical error for LSST are greatly smaller than that of CFHT and SNAP survey especially at about $30 < l < 300$, they are still larger than their maximum variations of BAOs wiggles. Thus, the detection of BAOs with the ongoing and upcoming surveys such as LSST, CFHT and SNAP survey confront a technical challenge.

1. Introduction

In the early universe prior to recombination, the free electrons couple the baryons to the photons through Coulomb and Compton interactions, so these three species move together as a single fluid. The primordial cosmological perturbations on small scales excite sound waves in this relativistic plasma, which results in the pressure-induced oscillations and acoustic peak (Bond and Efstathiou, 1984; Eisenstein and Hu, 1998). The memory of these baryon acoustic oscillations (BAOs) still remain after the epoch of recombination. The BAOs leave their imprints through the propagating of photons on the last scattering surface and produce a harmonic series of maxima and minima in the anisotropy power spectrum of the cosmic microwave background (CMB) at $z \approx 1000$. In addition, due to the significant fraction of baryons in the universe, BAOs can also be imprinted onto the late-time power spectrum of the non-relativistic matter (Bond and Efstathiou, 1984; Hu and Sugiyama, 1996; Eisenstein and Hu, 1998), which have been detected in the large scale correlation function of sloan digital sky survey (SDSS) luminous red galaxies (Eisenstein et al., 2005), and the power spectrum of 21 cm emission generated from the neutral hydrogen from the epoch of reionization through the underlying density perturbation (Mao and Wu, 2008; Chang et al., 2008). Essentially, the BAOs can give rise to the wiggles in the matter power spectrum of large scale structure during the evolution of the universe. Gravitational lensing can directly reveal the strength of gravitational clustering (Pen et al., 2003; Chen, 2005), and weak gravitational lensing is the direct measurement of the projected mass distribution of the large scale structure (Mellier, 1999; Bartelmann and Schneider, 2001; Refregier, 2003; Lewis and Challinor, 2006; Munshi et al., 2008). Therefore, the BAOs prior to recombination should also be imprinted onto weak lensing power spectrum. Recently, the influence of baryons on the weak lensing power spectrum are investigated by many works (White, 2004; Zhan and Knox, 2004; Jing et al., 2006). Zhang (2008) study self calibration of galaxy bias in spectroscopic redshift surveys of baryon acoustic oscillations to show that SKA is able to detect BAO in the velocity power spectrum, and the precision measurement of cosmic magnification are also demonstrated (Zhang and Pen, 2005; Zhang and Pen, 2006). The ongoing and

* Corresponding author. Address: Department of Astronomy, Beijing Normal University, No. 19 Xinjiekouwai Street, Beijing 100875, PR China. Tel.: +86 10 58807832; fax: +86 10 58806319.
E-mail address: tjzhang@bnu.edu.cn (T.-J. Zhang).

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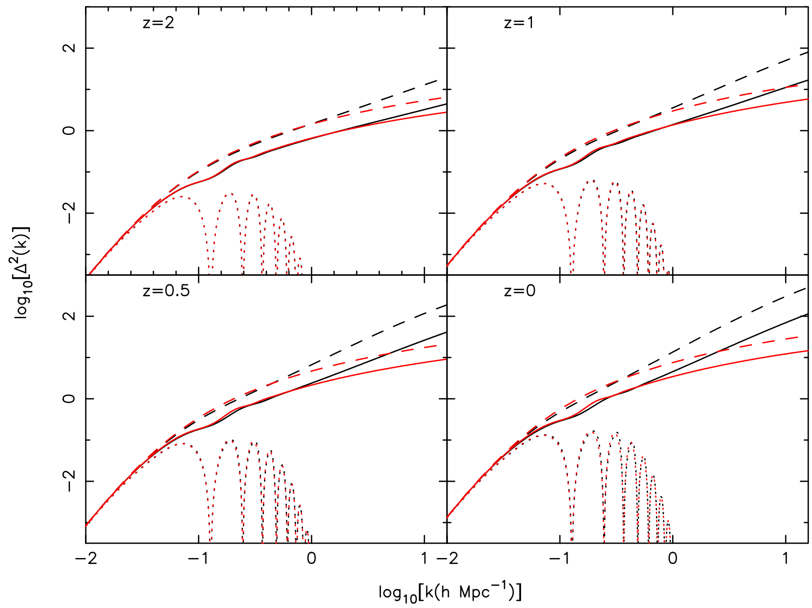

Fig. 1. Matter power spectra for three different matter contents: pure CDM (dashed line), pure baryons (dotted line) and mixed baryons + CDM (solid line) at redshift $z = 2$, 1, 0.5 and 0, respectively. The black lines correspond to the nonlinear power spectra of matter, while the red ones the linear power spectra. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

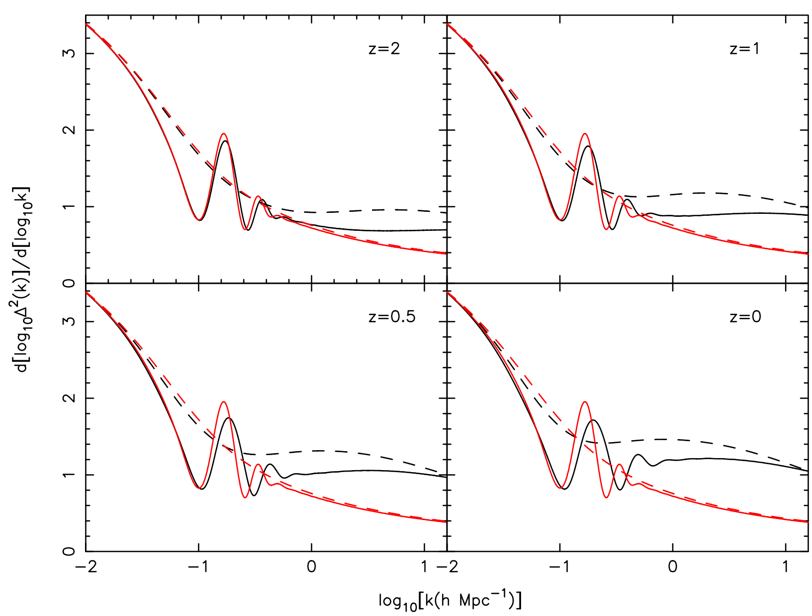

Fig. 2. The first derivative of power spectrum $\log_{10}\Delta^2(k)$ with respect to $\log_{10}k$ for pure CDM (dashed line) and mixed baryons + CDM (solid line) at redshift $z = 2$, 1, 0.5 and 0, respectively. The black lines correspond to the nonlinear power spectra of matter, while the red ones the linear power spectra. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

upcoming surveys such as the Canada–France–Hawaii-Telescope (CFHT) Legacy Survey,[1] the SuperNova Acceleration Probe[2] (SNAP) and the large synoptic survey telescope[3] (LSST) will significantly reduce the statistical errors to a few percent level in the measurement of weak lensing power spectrum. Therefore, it is necessary to explore the feasibility of detecting the BAOs in weak lensing surveys. In this paper, we concentrate on the wiggles of BAOs on the power spectrum of weak lensing by large scale structure and their detectability for current weak lensing survey.

2. Matter power spectra

We express the linear matter power spectrum in dimensionless form as the variance per unit logarithmic interval in wavenumber ($\log_{10}k$)

$$\Delta^2(k,z) = \frac{k^3P(k,z)}{2\pi^2} = \delta_H^2\left(\frac{k}{H_0}\right)^{3+n_s}T^2(k)\frac{D^2(z)}{D^2(0)}, \quad (1)$$

[1] http://www.cfht.hawaii.edu/Science/CFHLS/.

[2] http://snap.lbl.gov: SNAP is being proposed as part of the joint dark energy mission (JDEM).

[3] http://www.lsst.org.