

【大学院学生】

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物理学特別講義BXVI
(科目番号:35603-1361)

レポート(樽家先生)

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＜注意事項＞

表紙に学生証番号・氏名を必ず記入すること。

教務時間外は入口横のポストに入れてください レポート提出時に授業アンケートの実施にご協力ください。

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理学系研究科 物理学専攻教務

Assignment on Special topics in Physics BXVI (35603-1361)

Intensive course on “Cosmology with Large-scale Structure” (15–17 Nov. 2016)

Due date: 22nd Dec.

Submitted to #208 (教務) @ Faculty of Science Bldg. 1

- [1] Derive Eq. (2.52). For a quantitative estimate of k_{eq} , you may use $\Omega_{r,0}h^2 = 4.155 \times 10^{-5}$:

$$k_{\text{eq}} \equiv a_{\text{eq}} H_{\text{eq}} = \sqrt{\frac{2}{\Omega_{r,0}H_0^2}} \frac{\Omega_{m,0}H_0^2}{c} = 0.0095 \left(\frac{\Omega_{m,0}h^2}{0.13} \right) \text{ Mpc}^{-1}. \quad (2.52)$$

- [2] Derive Eq. (2.57):

$$r_s(\eta) = \frac{2}{3k_{\text{eq}}} \sqrt{\frac{6}{R_{\text{eq}}}} \ln \left(\frac{\sqrt{1+R(\eta)} + \sqrt{R(\eta)+R_{\text{eq}}}}{1 + \sqrt{R_{\text{eq}}}} \right). \quad (2.57)$$

- [3] Using Eqs. (4.2) and (4.4), derive the critical value δ_{crit} in Eq. (4.5) (see below):

$$\delta_{\text{crit}} \equiv \delta_{\text{lin}}(t_{\text{coll}}) = \frac{3}{20}(12\pi)^{2/3} \simeq 1.68647, \quad (4.5)$$

where t_{coll} is the collapse time, $t_{\text{coll}} = t(\theta = \pi/2)$. The δ_{lin} is the linearized density contrast whose expression is derived by taking the limit, $\theta \ll 1$ [**Hint**: you must take the limit in both $\delta(\theta)$ and $t(\theta)$ to obtain $\delta_{\text{lin}}(t)$].

- [4] Using Eq. (4.47) and Eq. (4.54), derive Eq. (4.55):

$$B(\mathbf{k}_1, \mathbf{k}_2, \mathbf{k}_3) \simeq \{D_1(a)\}^4 \left\{ 2F_2(\mathbf{k}_1, \mathbf{k}_2)P_0(k_1)P_0(k_2) + (\text{cyclic perm.}) \right\}. \quad (4.55)$$

- [5] Consider the gravity-induced non-Gaussianity. A simple non-Gaussian indicator is the skewness defined by:

$$S_3 \equiv \frac{\langle \{\delta(\vec{x})\}^3 \rangle}{\langle \{\delta(\vec{x})\}^2 \rangle^2},$$

where the quantities in the numerator and denominator are related to the Fourier-space correlators through

$$\langle \{\delta(\vec{x})\}^n \rangle = \int \frac{d^3\mathbf{k}_1 \cdots d^3\mathbf{k}_n}{(2\pi)^{3n}} \langle \delta(\mathbf{k}_1) \cdots \delta(\mathbf{k}_n) \rangle e^{i(\mathbf{k}_1 + \cdots + \mathbf{k}_n) \cdot \vec{x}}.$$

Show that the leading-order calculation based on the perturbation theory up to the second order gives

$$S_3 \simeq \frac{34}{7}.$$

Hint : To compute the denominator of S_3 , you may use the linear theory result, $\delta \simeq \delta_1 = D_1(a) \delta_0(\mathbf{k})$ to obtain

$$\langle \{\delta(\vec{x})\}^2 \rangle \simeq D_1(a)^2 \int \frac{dk k^2}{2\pi^2} P_0(k).$$

For the numerator, the leading-order expression of the bispectrum has to be used [see Eq. (4.55)]. With the explicit functional form of the kernel F_2 [Eq. (4.37)], the numerator is then reduced to

$$\langle \{\delta(\vec{x})\}^3 \rangle \propto \left[D_1(a)^2 \int \frac{dk k^2}{2\pi^2} P_0(k) \right]^2.$$

Note. All the equation numbers indicated above are those presented in the lecture note. The lecture note is downloaded from <http://www2.yukawa.kyoto-u.ac.jp/~atsushi.taruya/lecture.html>.