

## 15th June 2020

### 1 Basic reading

Dodelson ch-7. Inhomogeneities : reproduce the plot in figure 7.11 using the BBKS transfer function - read the whole chapter and reproduce other plots.

### 2 Advanced reading

Read the introduction of <https://arxiv.org/pdf/1706.09906.pdf> and summarize it.

### 3 Try N-body sims

Do a particle mesh code following the tutorial by Andrey Kravstov <https://astro.uchicago.edu/~andrey/Talks/PM/pm.pdf>

## 22nd June 2020

- Do  $\sigma_8$  normalisation of BBKS power spectrum and generate gaussian random field with that power spectrum.
- Visualise the generated gaussian random field in physical space and compare with the power law one.
- Read more about halo bias.

## 29th June 2020

- Similar to the smoothed variance  $\sigma_8$ , derive smoothed correlation function with different arbitrary smoothing.
- Take particle positions in snapshot\_200\* of simulation scm1024 and use CIC code to get density field. Visualise and compute power spectrum.
- Smooth it and then visualize and compute power spectrum.
- Read more about halos from Cooray and Sheth section 3.

## Correlation function power spectrum relation

$$P(\vec{k}) = \int \xi(\vec{r}) e^{i\vec{k}\vec{r}} d^3r \quad (1)$$

$$\xi(\vec{r}) = \frac{1}{(2\pi)^3} \int P(\vec{k}) e^{-i\vec{k}\vec{r}} d^3k \quad (2)$$

$$\xi(r) = \frac{4\pi}{(2\pi)^3} \int_0^\infty P(k) k^2 \frac{\sin(kr)}{kr} dk \quad (3)$$

$$\xi(r) = \frac{1}{2\pi^2} \int_{-\infty}^\infty P(k) k^3 \frac{\sin(kr)}{kr} d(\ln k) \quad (4)$$

$$\xi(r) = \int_{-\infty}^\infty \Delta^2(k) \frac{\sin(kr)}{kr} d(\ln k) \quad (5)$$

## $\sigma_8$ normalisation

It is defined as the root mean square of density variation after smoothing by correlating with spherical tophat function of radius  $8 \text{ h}^{-1} \text{ Mpc}$ . In fourier space, this is equivalent to multiplying by the fourier transform of that tophat .

$$W_s(k) = 3 \frac{j_1(kR_8)}{kR_8} \quad \text{where } R_8 = 8 \text{ h}^{-1} \text{ Mpc} \quad (6)$$

$$\sigma_8 = \sqrt{\frac{1}{(2\pi)^3} \int W_s^2(k) |\delta(\vec{k})|^2 d^3k} \quad (7)$$

$$\sigma_8^2 = \frac{1}{(2\pi)^3} \int W_s^2(k) |\delta(\vec{k})|^2 d^3k \quad (8)$$

$$= \frac{1}{(2\pi)^3} \int W_s^2(k) |\delta(\vec{k})|^2 k^2 dk d\Omega \quad (9)$$

$$= \frac{1}{(2\pi)^3} \int W_s^2(k) k^2 dk \int |\delta(\vec{k})|^2 d\Omega \quad (10)$$

$$= \frac{1}{(2\pi)^3} \int W_s^2(k) k^2 4\pi P(k) dk \quad (11)$$

$$= \frac{1}{2\pi^2} \int W_s^2(k) k^2 P(k) dk \quad (12)$$

$$= \int W_s^2(k) \Delta^2(k) d(\ln k) \quad (13)$$

That integrand drops away from the that  $8 \text{ h}^{-1} \text{ Mpc}$  scale

**Correlation after smoothing:**

$$\xi_{s_1, s_2}(r) = \int_{-\infty}^{\infty} \Delta^2(k) W_{s_1}(k) W_{s_2}(k) \frac{\sin(kr)}{kr} d(\ln k) \quad (14)$$

# Large Scale Structure notes

Inhomogeneous evolution can't be done completely analytically, even though it can be simulated. Analytical tools/models are important to gain deeper understanding. Simulations help in making, testing and refining these analytical tools along with the observations.

## 1 FLRW background evolution

## 2 Newtonian equations for inhomogeneous CDM

## 3 Growth of Structure

### 3a Linear solutions to inhomogeneous CDM

### 3b Eulerian - 2nd order perturbation theory

### 3c Lagrangian approach - Zel'dovich approximations

### 3d Spherical collapse

## 4 Halo Model

### 4a Halo Bias

Split  $\delta(\vec{x})$  into small scale and large scale components.

## Halo assembly bias