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 σ_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 σ_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

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

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

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

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

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

σ_8 normalisation

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

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

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

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

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

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

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

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

$$= \int W_s^2(k) \ \Delta^2(k) \ d(\ln k) \tag{13}$$

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

Correlation after smoothing:

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

Large Scale Structure notes

Inhomonenous evolution can't be done completely analytically, eventhough 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