OBSERVATIONAL COSMOLOGY

PROBLEM SHEET 6 - 06/07/2017

1) Compute the power spectrum for a random distribution of N points in a volume V, with density $\bar{n}$. *Hint: think of the contributions of self pairs (i.e. of a particle with itself) to the 2-point correlation function and remember that the power spectrum is*

$$P(k) = 4\pi \int_0^\infty \mathrm{d}r\, r^2 \xi(r) \frac{\sin(kr)}{kr}\,. \tag{1}$$

2) Suppose the relation between the galaxy overdensity and the matter one is:

$$\delta_g = b_0 + b_1\,\delta_m + \frac{b_2}{2}\,\delta_m^2\,, \tag{2}$$

with b_i some bias parameters. Write down the relation between the power spectrum of the galaxies and of the matter, assuming that δ_m is a Gaussian random field (i.e. its odd-order moments vanish).

Power spectrum definition:

$$(2\pi)^3 P(k)\delta_D(\mathbf{k}+\mathbf{k}') = \langle \tilde{\delta}_m(\mathbf{k})\tilde{\delta}_m(\mathbf{k}')\rangle \tag{3}$$

Fourier transform conventions:

$$\tilde{\delta}(\mathbf{k}) = \int \mathrm{d}\mathbf{x}\, \mathrm{e}^{i\mathbf{k}\cdot\mathbf{x}}\delta(\mathbf{x})\,, \tag{4}$$

$$\delta(\mathbf{x}) = \frac{1}{(2\pi)^3}\int \mathrm{d}\mathbf{k}\, \mathrm{e}^{-i\mathbf{k}\cdot\mathbf{x}}\tilde{\delta}(\mathbf{k})\,. \tag{5}$$

3) Consider two galaxies separated by a redshift interval $\delta z \ll 1$ and at an angular separation, as observed from Earth, $\Theta \ll 1$ rad:

I Write the espressions for the *physical* separations $r_\perp$ and $r_\parallel$, perpendicular and parallel to the line-of-sight direction.

II The results from (I) clearly depend on the choice of the cosmology. If you assume the wrong cosmology, what is the relation between your $r_\perp$ and $r_\parallel$ and the ones computed for the true cosmology, $r_{t\perp}$ and $r_{t\parallel}$? How does the 2-point correlation function measured assuming the wrong cosmology relate to the true one? (Consider that in the true cosmology ξ should be isotropic: $\xi_t(r_\perp, r_\parallel, z) = \xi_t(r_\parallel, r_\perp, z)$). And the power spectrum?

III Nonetheless, there are effects which generate anisotropy in redshift space, for instance the so-called "Fingers of God". Consider a spherical galaxy cluster of radius R = 1 Mpc, with uniform galaxy density n = 25 gal/Mpc^3 and velocities that follow the Maxwell-Boltzmann distribution, with a 3D velocity dispersion of 1000 km/s. What is the observed galaxy density distribution along a line of sight which passes through the centre of the cluster, if the cluster lies at $z = 0.1$ or at $z = 1$?