OBSERVATIONAL COSMOLOGY

Problem sheet 5 – Due 21/05/2019

1) 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 down the expressions 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 cosmology. If you assume a 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 ξ measured assuming the wrong cosmology relate to the true one? (Consider that in the true cosmology ξ must 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 $z = 1$?

2) You can design your own redshift survey, but the telescope allocation committee just gave access to you for 2 calendar years. You need $\Delta t = 2\left(\frac{n}{1\text{Mpc}^{-3}}\right)^{1/2}$ hours of integration time to get a galaxy spectrum (fainter galaxies are more abundant than brighter galaxies but longer integration time is needed to take their spectra), where n is the average galaxy density, and your multifiber spectrograph can handle 100 fibers simultaneously. You can choose to sample only a random fraction of the galaxies $n_{obs} = \epsilon \cdot n$, with ϵ being the sampling rate. Assume that you will survey a cubic region of space at $z \sim 0$ with volume L^3. You are interested in the mean power in the bin $0.08 < k < 0.12\, h\,\text{Mpc}^{-1}$; assuming a Gaussian density field, choose the target density n, the sampling rate ϵ and the survey size L that optimize the measure of the galaxy power spectrum in the selected wavenumber interval.

Hint: the measurement error for the power spectrum can be found in slide III-71. The number of Fourier modes contained in a k bin with edges $k_{\min}$ and $k_{\max}$ can be computed by taking the ratio between the total k-space volume covered by the bin and the volume occupied by the fundamental cubic cell of size $k_{\text{f}} = 2\pi/L$.

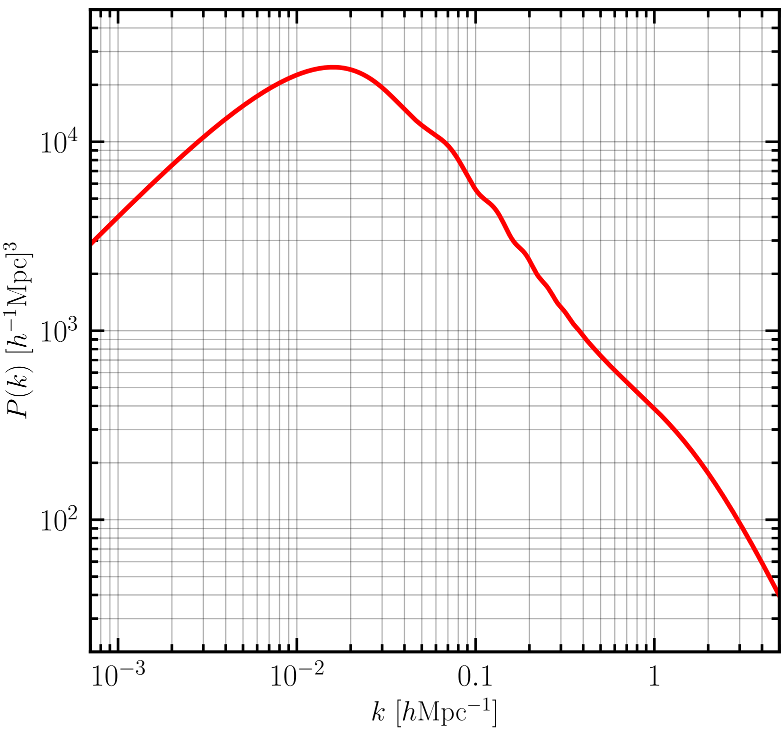

Figure 1: The matter power spectrum at redshift $z = 0$