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Problem Sheet #5

(Hand out: Thu => hand in: max Fri 16th)

Solve the analytical and numerical exercises below.

1. Galaxies, redshift, and the distance-redshift relations
The stellar disk of the Milky Way has a radius of about 15kpc and a bolometric luminosity Lbol. Plot the apparent angular diameter and the bolometric flux (in units of Lbol) of a Milky Way-like galaxy (seen face on) as a function of its redshift assuming H0= 100 h km/s/Mpc with h = 0.7 and assuming different cosmological scenarios:

- an Einstein-de Sitter universe
- a de Sitter universe
- A universe like ours: see above.

Write down the corresponding values at z= 0.1, 1, 3, and 6.

Hint: plot the proper distance, angular diameter distances and bolometric fluxes as a function of redshift for the three aforementioned cosmological models.

2. The Horizon Size
Estimate the angle theta_h subtended by a region whose transverse length is equal to the size of the particle horizon (the distance a photon can travel since the Big Bang) at redshift z~1100, the redshift of the last scattering. If we were able to measure theta_h, what cosmological parameters could we constrain?

3. The dependence on cosmological parameters of the abundance of massive objects
Take the prescription for the dark-matter halo mass function from Tinker et al. 2008 and quantify how the various cosmological parameters affect it.
Consider varying sigma8, Omega_m, and h one at the time all by the same relative uncertainty (e.g. 3 per cent). Firstly, focus on the 10^12-15.5 Msun range at z=0: what cosmological parameter is the abundance of haloes most sensitive to? What masses are most sensitive to the changes in cosmological parameters? Secondly, consider the parameter that most affects the halo abundance at the current epochs: show its impact on the halo abundances as a function of redshift, 0<z<2. Are high-redshift haloes more or less sensitive to variations in the parameter?

Hints: write/calculate the mass function as dn/dM and calculate it for a fiducial cosmological model (e.g. Table in Problem Sheet #2). Perturb such model by changing the values of its parameters one at the time, by a fixed relative amount (e.g. fiducial + 3% and fiducial - 3%). Recalculate the mass functions for the perturbed models. With 3 parameters, and 3 values each, you should have 9 realizations of the Tinker mass function at a given redshift. Quantify the relative effects on dn/dM of the changes in parameter values, by plotting MF= dn/dM vs. M and the ratios MF(fiducial + 3%)/MF(fiducial) vs. M and MF(fiducial -3%)/MF(fiducial) for each parameter