HW 6

Due Thursday March 10, 2016

This is a shorter than usual deadline, so it’s much shorter than usual assignment.

Please answer all questions clearly and concisely. You are strongly encouraged to discuss the homework with your classmates, but you must complete the written homework by yourself, and of course, the material you submit must be your own.

1. Consider the acoustic peaks in the CMB spectrum. We will vary cosmological parameters. In each case, we will be doing a comparison with the concordance model: $\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$, $\Omega_K = 0$, $\Omega_b = 0.04$, $n = 1$, $\sigma_8 = 1$. For reference, the position of the first peak is observed (and predicted for this model) to be at $l=220$. Thus, the only calculations you need to do will be relative to this value.

(a) Imagine that the universe contained no cosmological constant, and thus, had negative curvature. The matter density is still the same. At what value of $l$ would the peak be observed? Would you expect anything else to change?

(b) Imagine that $\Omega_M = \Omega_b = 0.3$ (curvature still equal to zero). Assume decoupling occurs at the same time as in the concordance model (which is close to true). The sound speed would (naturally) be lower than in the concordance model. Around what $l$ would we expect to find the peak? You may need to refer back to a previous homework for some guidance.

(c) Assume a universe, with $\Omega_M = 0.3$, but which may be curved. Make a plot showing the position of $l_{\text{peak}}$ as a function of $\Omega_b$, and $\Omega_\Lambda$.

2. Let’s talk about the spherical collapse model. The Local Group of galaxies has an approximate mass of $5 \times 10^{12} M_\odot$, and has an approximate radius of 1 Mpc. Assume $\Omega_M = 0.3$, and $h = 0.7$.

(a) What is the overdensity of the Local Group?

(b) The matter now in the local group was collapsed from a larger region of space. Assuming it collapsed a sphere, what was the initial comoving radius?

(c) Using the results from class, and assuming that the Local group began to collapse when $z = 0.5$, what was the radius of the density perturbation at turnaround? Give both the comoving and proper sizes.