Physics of Cosmic Structures: week 9 exercises

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To successfully pass the exam, it is important to note that regular exercises labeled with [R] are mandatory. On the other hand, exercises marked with [S] are considered speculative and are not compulsory. You may choose to work on these exercises at your discretion.

It is highly recommended to work on regular exercises independently as it can help build a strong, individual understanding of the topic. However, for speculative exercises, collaborating with others is not only allowed, but also encouraged. Group work can foster creativity and facilitate idea sharing, leading to a more fulfilling learning experience.

Do not hesitate to ask questions.

I. PROBLEM 1: CMB PARAMETER SENSITIVITY [R]

The standard cosmological model, ΛCDM, is defined by the values of six parameters: $(A_s, n_s, \tau, H_0, \Omega_b h^2, \Omega_c h^2)$.

Explore the CAMB example notebook and familiarize yourself with the different quantities that the code computes and can plot.

Run CAMB for reference values of these parameters (either CAMB default of Planck 2018 best-fit results). Plot the CMB temperature power spectrum. Plot the monopole, dipole, early/late ISW contributions to the spectrum (check the extra example notebook that is provided with CAMB).

Vary these parameters by 10% of their value. Plot both the full temperature spectrum and different contributions (monopole, dipole, early/late ISW). How and why do they change? Describe these changes and why they are happening.

You can find it useful to use the markdown feature of jupiter notebooks that allows you to mix text and code and take a note of your results (i.e. write down your considerations, you do not need to memorize them for the exam).

II. PROBLEM 2: CMB AND NEW PHYSICS [R]

Pick a parameter that is not related to the six base ΛCDM parameters and describes some sort of physics beyond the standard model that you like.

Repeat the previous exercise varying it around its ΛCDM value and describe the effect it has on the CMB power spectrum and its different components.

Download the measured Planck power spectrum from the Planck legacy archive `https://pla.esac.esa.int/#cosmology` Plot the data points, with error bars, on top of your model predictions. Do you think that Planck measurements would be able to tell the difference between the two models?

In case you have not used the Planck best fit you can just add the error bars on top of the baseline model predictions.

III. PROBLEM 3: POWER ANIMATIONS [S]

Browse around at `http://background.uchicago.edu/~whu/metaanim.html`. Those beautiful gifs might use a refresher? What would be a good format? What makes a beautiful plot?