

Homework 4: Due Tuesday October 10

READING 1: <http://background.uchicago.edu/~whu/beginners/introduction.html> and grab the 2MB PDF file by Hu and White mentioned at the very bottom of the page

1. (10 points) Microwave Background Radiation (Based on Reading 1)

- What is a power spectrum? It is a plot of something versus something else, but explain what the somethings are.
- What is the first peak of the power spectrum and what does it allow us to measure?
- Where is the WMAP telescope? What major discoveries has it made?
- Why is the second peak in the power spectrum lower than the first?
- Why does the cosmic microwave background come from a time 380,000 years after the Big Bang? What happened at that time that was significant?

2. (4 points) Nucleosynthesis

What is the mass fraction of ${}^4\text{He}$ produced in the Big Bang if the neutron to proton ratio is $1/5$ at the time when nucleosynthesis begins? What if the neutron to proton ratio is $1/9$?

3. (8 points) Horizons

Assume that the universe is flat and that $\Omega_{\text{matter}} = 1$ so that the scale factor, R , is proportional to $t^{2/3}$. Also, the density of the universe at present is $1 \times 10^{-29} \text{g/cm}^3$. The mass of a proton is $1.67 \times 10^{-24} \text{g}$. 1 light year = $9.5 \times 10^{17} \text{cm}$. $1M_{\odot} = 2 \times 10^{33} \text{g}$.

- What is the mass in our horizon of the universe at present if the universe is 14 billion years old?
- The density increases as we go back in time, and it increases at a rate inversely proportional to the volume. Calculate the density of the universe at decoupling (300,000 years after the Big Bang). Hint: you will have to work out the change in the scale factor using the times.
- What would the mass in the horizon have been at decoupling (300,000 years after the Big Bang)?
- What is the significance of the difference in the mass in the horizon between decoupling and the present and how does it relate to inflation?

4. (4 points) Essay Question (response should be about 1-2 pages)

On Oct. 5, Bob Fedorchak, an expert advisor from the Eberly College of Science is visiting our class. He will speak about science-related careers and about what you can do about an astronomy degree. Summarize what he said during his presentation and emphasize aspects that might be relevant to you.

5. (4 points) Question to the professor. Write a question about something that you are still wondering about. I will answer your question on your graded homework.