Phys 10 Homework 10 Solutions (Not to be turned in, not part of your grade)

Assigned: Mar 11
Solutions provided Mar 11

The idea of this homework set is to help you study for the final exam. You should use it the same way you use the other homeworks as a guide to prepare for exams. Solutions are posted on the main course web page in the assigned homework section.

Most of these topics received more emphasis in my lectures than in the textbook.

10.1) What are the three cosmological puzzles of the standard big bang theory that motivate the theory of cosmic inflation? Name them and describe each using a sentence or two.

Flatness Puzzle: The standard big bang tends to evolve away from flatness over time. Despite the fact that this has been going on for 14 Billion years, the data show the universe is flat today with uncertainties of just a few percent. This requires $\rho = \rho_c$ to many decimal places in the early universe.

Homogeneity Puzzle: The standard big bang tends to undergo clumping of matter due to the force of gravity that tends destroy homogeneity. Despite the fact that this clumping has been going on for 14 Billion years the universe is observed to be remarkably homogeneous. This requires that the universe must have been extremely homogeneous in the early universe.

Horizon Puzzle: Information can only travel a finite distance since the big bang. Regions within this distance (set by the distance light has traveled since the initial singularity) are said to be in "causal contact". In the early universe the size of a region in causal contact was vastly smaller than the size of the region of the universe we now observe, so it is hard to imagine physical processes (which are limited by the speed of light) could set up the special conditions required to explain the Flatness and Homogeneity.

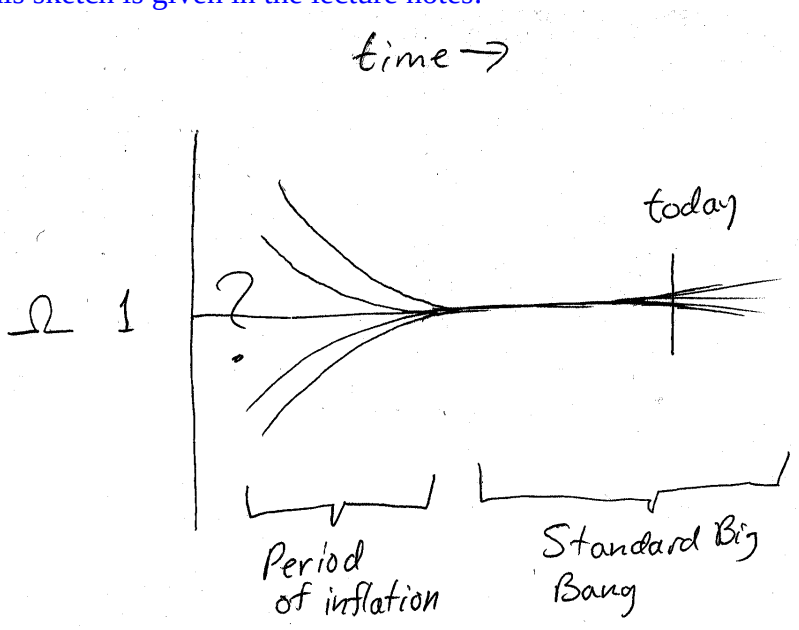
10.2) What aspect of the universe must you care about for the puzzles stated in 10.1) to really be "puzzles" rather than simply being "features" of the standard big bang picture of cosmology?

You must care about explaining how the big bang got started to be puzzled by the above. Otherwise these are just features of the standard big bang picture.

10.3)

a) Sketch a pot of $\Omega(t)$. Along the "x-axis" (time) mark an early time period as the time of "inflation" followed by a later time period for the "standard big bang". Show several different curves that show typical behaviors of $\Omega(t)$ during these periods.

This sketch is given in the lecture notes:



b) Write (in a few words) what is happening to the flatness of the universe during these two periods.

The flatness of the universe is **decreasing** during the standard big bang phase and **increasing** during inflation.

10.4)
a) according to current data, what percent of the universe is in Dark Energy, Dark Matter, and "ordinary matter" (such as we actually have studied in the laboratory). *You need only give three numbers here, without explanation.*

Dark Energy: 70%
Dark Matter: 25%
Ordinary Matter: 5%

b) What aspect of the Dark Energy makes it radically different that the Dark Matter and "ordinary matter".

Dark Matter and ordinary matter experience an attractive (clumping) force of gravity, whereas Dark Energy tends to push the universe apart.

10.5) True or False *(Please give a brief explanation of your answer)*
a) Physicists have a very clear understanding of the Dark Energy

False: The dark energy (and the cosmic acceleration it attempts to explain) is very poorly understood. Each possible theory for the dark energy has serous problems.

b) There are several good experiments we could do to learn more about the dark energy.
True: The Dark Energy Task Force recommended several projects that could greatly increase the data on dark energy and cosmic acceleration.