3C74: TOPICS IN MODERN COSMOLOGY

Problem Sheet 4: Answers to be handed in by 25 April 2005
(Please put them in my pigeon hole or under my office door.)

Question 1

Write down the reaction that converts neutrons to protons in the early Universe when the particles are in thermal equilibrium.

Explain briefly why thermal equilibrium will come to an end.

In the cosmic production of ^{4}He, the neutron half-life effectively determines the amount of ^{4}He produced. If the neutron half-life was 900 s instead of the usual value of 614 s, calculate (using the equations in your notes) the resulting mass-fraction Y_4 of He.

Question 2

The Friedmann equation can be written as an equation showing how the density parameter Ω varies with time

$$|\,\Omega(t) - 1\,| \;=\; \frac{|\,k\,|}{a^2\,H^2}.$$

Using the solutions for radiation- and matter-dominated Universes ($a \propto t^{1/2}$; $a \propto t^{2/3}$), show how Ω varies with time, and explain the ensuing "flatness problem".

Assuming a radiation-dominated Universe, estimate how close Ω was to unity at an age of $t = 10$ s, if today ($t_0 = 1.4 \times 10^{10}$ yr) we measure $\Omega_0 = 0.3$.

By considering the Friedmann equation as given above, explain how the concept of inflation can solve the flatness problem.

Describe two other failures of the Big Bang model and explain how inflation can solve these problems.