UNIVERSITY OF BIRMINGHAM

DEGREE OF B.SC. & M.PHYS. WITH HONOURS

FINAL EXAMINATION

03 00716

(OBSERVATIONAL COSMOLOGY)

MAY/JUNE, 2003

*Answer any **two** questions. If you answer more than two questions, only the first two answers in you answer books will be marked.*

*The **approximate** allocation of marks to each part of a question is shown in brackets* **[ ]**.

Total time allowed: 1.5 Hours

A table of physical constants and units that may be required will be found at the end of this question paper

(Turn Over)

1. (a) Calculate the present energy density in the cosmic microwave background, and the number density of photons in the Universe. You may assume that the cosmic microwave background photons make the only significant contribution and other photons can be ignored. Using this result, or otherwise, show that the ratio of the number of photons to baryons in the Universe is about 2x10^9. [4]

   (b) Show that the Universe today is matter dominated. How can a matter dominated Universe be reconciled with the photon to baryon ratio in part (a)? [3]

   (c) Estimate the redshift at which the energy densities of radiation and (total) matter were equal. Calculate the radiation temperature at this redshift. [3]

   (**Note:** the radiation constant $\alpha = 7.565\text{x}10^{-16}$ J m^{-3} K^{-4})

2. (a) Discuss in detail the major problems with the hot Big Bang model and explain how the idea of inflation may be used to solve them. [6]

   (b) What is the evidence that suggests it is unlikely that the density of baryons in the Universe is equal to the critical density? Why may dark baryons be required? [4]

3. (a) A standard observation by astronomers is to count stars or galaxies as a function of their observed flux. Show that the number N of nearby stars brighter than flux S in our Galaxy is given by
   $N(> S) = N_0 S^{-1.5}$
   where N_0 is a constant. Assume all the stars have the same intrinsic luminosity and are distributed uniformly.
   Now consider the same relation, but for galaxies. Why might the observed number of galaxies deviate from the above relation? Explain whether the deviation would increase or decrease for fainter and fainter galaxies, and why. [5]

   (b) Explain briefly how you might measure the peculiar velocity of a galaxy.
   What limitations would there be in the measurement? [3]

   (c) In a flat, matter-dominated Universe (with zero cosmological constant), show that the density of matter varies with time as $\rho_m \propto t^{-2}$ [2]

THE STANDARD TABLE OF CONSTANTS SHOULD BE ATTACHED MANUALLY - NO REASON TO PREPARE IT IN TEX.

(Turn Over)