## PHY306 QUESTIONS FOR GOTT ET AL 1974

**Answer all questions. Some questions may require you to consult other sources: if so, remember to reference the sources used in standard style (see the Department's web page on "Plagiarism and Collusion" for instructions on referencing). Always use your own words, unless there is justification for a brief direct quote—if there is, use quotation marks. This exercise counts 5% towards your total module mark.**

1. Bearing in mind that this paper was written in 1974, discuss carefully what the authors' motivation for writing it is—i.e., what problems or open questions are they hoping to solve, and why is this an appropriate way to approach them? [2]

2. The first set of constraints discussed by Gott et al. concern limits on the age of the universe. Briefly explain why these limits yield the curves shown in their Figure 1—i.e., why on this plot the limits are first flat and then curve downwards, and why the values of $H_0$ at small $\Omega$ are roughly 52 and 120 km $s^{-1}$ $Mpc^{-1}$ for the upper and lower age limits respectively. [Hint: what is the age of the Universe, in terms of $H_0$, for a model with constant a? And what is it for a matter-only universe with $\Omega_{m0} = 1$?] [3]

3. The next set of constraints considers the value of $q_0$ derived from various indicators. Discounting, as Gott et al. do themselves, the technical argument in section III(e), what is the problem with these measurements? Are they still used in cosmology, and (if so) for what purpose(s)? [3]

4. In Section IV, Gott et al. consider a number of direct limits on $\Omega$, and in section V they discuss the abundance of deuterium. Combining all these results, they conclude that their best estimate is $\Omega_{m0} \approx 0.06 \pm 0.02$. This does not compare well with our current best estimate of $\Omega_{m0} = 0.27$. Discuss what has gone wrong (bearing in mind that these people are not idiots: the late Dave Schramm in particular was a cosmologist of real distinction). [4]

5. In section VII, the authors discuss possible sources of "missing mass" if it is "demanded on theological or other grounds that $\Omega \geq 1$". With hindsight, none of their suggestions is actually the preferred modern model of dark matter. Explain why post-1974 data prefer a different solution to the problem, and suggest reasons why Gott et al. missed this possibility. [3]