Birla Institute of Technology and Science, Pilani-Hyderabad Campus 28th Jan (Tuesday), 2020 Qualifying Examination (Open Book)

Course Title: COSMOLOGY 9.30AM -12.30PM

Total Marks: 75 Time: 3 hour

Instructions

- (i) Answer all questions. Marks for each question are given at the end of the question
- (ii) Start a new question in a new page and answer all its parts in the same place.
- (iii) Write all the steps clearly and give explanations for the complete credit.
 - The Friedman equation is:

$$\left(\frac{\dot{a}}{a}\right)^{2} = \frac{8}{3}\pi G\rho(t) - \frac{kc^{2}}{a^{2}R^{2}} + \frac{\Lambda}{3}$$

Here, the density $\rho(t)$ is the sum of the density of radiation, $\rho_r = \varepsilon_r/c^2$ and the density of matter, ρ_m

- (a) Express this in terms of ρ₌₀ and ρ₌₀, the present day densities of radiation and matter.
- (b) Express it in terms of Ω_r, Ω_m and Ω_Λ = Λ/3H², the density parameters at time t. [6]
- (c) Express it in terms of present-day values Ω_{r0}, Ω_{r0} and Ω_{A0}.
 [6]
- 2. Solve the Friedman equation for the case where the only contribution to the energy density of the universe comes from something which has equation of state p = ner where w is a constant whose value is greater than -1. Use the boundary condition that a = 0 at t = 0.

Find the relationship between the age of the universe t_0 and the current Hubble constant H_0 in this model.

In a universe which contains matter and is positively curved (i.e. Ω_{m0} > 1, k > 0, Ω_{c0} ≈ 0, Λ = 0 the Friedman equation can be written

$$\dot{a}^2=H_0^2\bigg(\frac{\Omega_0}{a}-(\Omega_0-1)\bigg)$$

where for convenience we have dropped the 'm' from the suffix since there is no other contribution to Ω .

- (a) Find an expression for the maximum possible value of a in this universe. Calculate a_{max} for the case Ω₀ = 1.1. What is the maximum possible value of Ω₀ for which a_{max} > 1 (i.e. the universe has not already collapsed)?
- (b) Show by differentiation that the parametric equations

$$a(\theta) = \frac{\Omega_0}{2(\Omega_0 - 1)}(1 - \cos \theta)$$

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Mernik, Marjan

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Reviewing Question Paper Physical Science Practical 2008 Msce: Unlocking the Spellbinding Force of Linguistics

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