

# PHYS 480/581 General Relativity

## Homework Assignment 14

Due date: Friday 05/03/2024 5pm, submitted electronically on UNM Canvas

### Question 1 (3 points).

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Our current Universe appears to be dominated by a cosmological constant. Compute the age of our Universe assuming that today (when the Hubble expansion rate is  $H_0 = 70$  km/s/Mpc) 70% of the energy is in the form of the cosmological constant and 30% is in the form of cold matter.

### Question 2 (4 points).

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Let's consider the flat FLRW metric

$$ds^2 = -dt^2 + a^2(t)[dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2)], \quad (1)$$

where  $a(t)$  is the scale factor. For this problem, use the value of the cosmological parameters provided in the inner front cover of Moore and assume a realistic universe filled with matter, radiation, and a cosmological constant. In cosmology, we often referred to epochs in the evolution of the Universe in terms of their *redshift*  $z$ , which is related to the scale factor by  $a(t) = 1/(1+z)$ .

- (a) Using the fact that photons always travel on null trajectories ( $ds^2 = 0$ ), compute the total comoving distance that a photon will travel from the Big Bang at  $t = 0$  to the epoch of recombination at redshift  $z = 1090$ .
- (b) Now compute the total comoving distance that a photon will travel from the epoch of recombination to the present time ( $z = 0$ ).