

PHYSICS 406: PROBLEM SET 7

Due: Tuesday, May 2

1.: Show that in radiation dominated universe,

$$R^{ab}R_{ab} \rightarrow \infty$$

as $a \rightarrow 0$. Hence, even for an equation of state of $1/3$, there is a big bang singularity.

2.: Because electrons combined with protons to form neutral hydrogen at temperature of about 1 eV, majority of the cosmic background photons that we see today last scattered off of charged particles at that temperature from a spherical surface very far away. This is called the “last scattering surface.”

a): Given that the temperature of the cosmic background photon today is about 10^{-3} eV, compute the redshift z_* at the last scattering surface.

b): Compute the physical distance (on the homogeneous spacelike hypersurface today) from Earth to the last scattering surface. (i.e. the last scattering surface occupies a fixed coordinate distance with respect to us today. Compute the physical distance between that surface and us where the spatial metric is defined on the homogeneous spacelike hypersurface today. Express your answer in cm units to order of magnitude accuracy.)

3.: Problem 9.3

4.: Problem 9.4