Exercise sheet 9

1. Christoffel symbols and the Ricci tensor
Find the Christoffel symbols and the Ricci tensor for the metric $dl^2 = S(t) [B(r)dr^2 + r^2 d\Omega]$.

2. Redshift
Derive the redshift of a photon in the FLRW metric analogous to the redshift of a photon in the Schwarzschild metric. Using the fact that homogenity leads to the existence of 3 space-like Killing vector fields.

3. New galaxies.
As the universe expands, the horizon grows. Estimate the time it takes for one galaxy entering the horizon assuming the universe to be matter-dominated.

4. Closed universe.
Consider the FLRW metric using conformal time $d\eta = dt/R$ for a closed matter dominated universe.

a.) Draw a $\eta - \chi$ space-time diagram for a closed matter dominated universe including big bang, big crunch and the past light cone of an observer at the origin at the moment of maximal expansion.

b.) Are there parts of the universe the observer can never see?

c.) Can an observer traverse the entire universe in the time between big bang and big crunch?

Solutions are discussed Friday, 08.04.22