General Relativity - Exercise session

Friday December 13, 2013

1. Use Friedmann's equations to argue that a flat universe consisting of radiation, matter and (positive) vacuum energy cannot undergo a transition from a contracting to an expanding phase. *Hint: this is easily shown considering a combination of Friedmann's equations such as in equation (8.86) in Carroll's book.*

2. Suppose our universe consists of radiation, matter and (positive) vacuum energy and that there is no interaction, i.e. these components are not converted in each other. Can you then determine whether the expansion of the universe accelerated or decelerated in the far past? And in the far future?

3. Consider the metric $ds^2 = -dudv + 2H(x, y, u)du^2 + dx^2 + dy^2$. What form must the function H have for this to represent a (plane) gravitational wave propagating in vacuum? What changes if we consider $H(x, y, u)$ as a perturbation around the Minkowski background $ds^2 = -dudv + dx^2 + dy^2$ in linearised Einstein's gravity?