Exercises for CMB and LSS

Lecturer: Björn Garbrecht **SS 2016**
Sheets by Wenyuan Ai **Sheet 5**
due until Tuesday, July 4, 2016 in class

Problem 1.
Show that on large scales the energy-momentum tensor satisifies

$$\frac{ik_i\delta T^0{}_i H}{k^2} = \frac{\delta T^0{}_0}{3}.$$

Hint: One way to do this is to combine Einstein's equations, the time-time and time-space components, and take the large-scale limit.

Problem 2.
Show that $\delta \propto H$ is a solution to the evolution equation

$$\frac{d^2\delta}{da^2} + \left(\frac{d\ln(H)}{da} + \frac{3}{a}\right)\frac{d\delta}{da} - \frac{3\Omega_m H_0^2}{2a^5H^2}\delta = 0,$$

if the universe is flat with a cosmological constant. You will need to use the Friedmann equation. Show also that the solution is valid if the universe has zero cosmological constant, but is open with $\Omega_m < 1$.

Problem 3.
Compute the growth factors in a universe with $\Omega_{de} = 0.7$, $\Omega_m = 0.3$ and $w = -0.5$. Plot as a function of a. Compare with the cosmological constant model ($w = -1$) with the same Ω_{de}, Ω_m.
Hint: One may need a more generic form of growth factor for $w \neq -1$ cases, which is different to the form on the lecture notes.