

Homework problems 2

Group II

Problem No 4.1

Future of the Universe

Find bounds on the maximal size and lifetime of the closed Universe assuming that dark energy instantaneously switches off right after the present epoch.

Problem No 4.15

Dark Energy equation of state from quintessence

In quintessence model with potential $V(\phi) = \frac{1}{2}m^2\phi^2$, find the present value of the dark energy equation of state parameter w as function of the present value $\phi(t_0) = \phi_0$. Choose the present value ϕ in such a way that $w_0 = 0.9$, and find $w(z)$ as function of redshift at $2 > z > 0$. Take the values $\Omega_\phi \equiv \Omega_\Lambda = 0.73$, $\Omega_m = 0.27$ and make use of the fact that the scalar field changes slowly at the present epoch.

Problem No 5.4

Chemical potential

Estimate the value of the chemical potential for u-quark at temperature 1 GeV.

Problem No 6.6

Hydrogen abundances at recombination

Find relative equilibrium abundances of hydrogen atoms at 2s- and 2p-levels at temperature $T_r^{eq} = 0.33$ eV. Disregard higher levels in this calculation.

Problem No 6.9

Inequilibrium density of electrons

Show that at recombination, when $n_e/n_B \ll 1$, the inequilibrium density given by Eq. (6.38) always exceeds the equilibrium one shown in Eq. (6.24). Consider only temperatures $T > 2500$ K. Make use of Sec. 6.2.