

Homework problems 2

Group I

Problem No 4.2

Redshift of the deceleration-to-acceleration transition epoch

At what z did the contribution to energy density due to non-relativistic matter and dark energy become equal to each other?

Problem No 4.8

Degeneracy of cosmological parameters

Show that to the order z^3 the degeneracy in parameters is removed, i.e., $r(z)$ given by (4.36) depends in a non-trivial way on all three parameters H_0 , Ω_M , Ω_Λ . Show, nevertheless, that in the interesting region of cosmological parameters there remains approximate degeneracy at moderate z along the line $2\Omega_M - \Omega_\Lambda = 0$.

Problem No 5.3

Relativistic particles in cosmic medium

Find the differences of the number densities of all relativistic Standard Model particles and their antiparticles in the cosmic medium at temperature $T = 400$ MeV for given densities of baryon and lepton numbers n_B , n_{L_e} , n_{L_μ} , n_{L_τ} in the realistic case $n_B, n_{L_e}, n_{L_\mu}, n_{L_\tau} \ll T^3$.

Problem 6.3

Chemical potentials at recombination

Find chemical potentials μ_e , μ_p , μ_H in equilibrium at temperature $T_r^{eq} = 0.33$ eV. Compare them with masses of electron, proton and hydrogen atom.

Problem 6.7

Electrons at recombination

Prove that if $1s$ atoms were not produced at all during recombination then practically all electrons would be free at the recombination temperature $T_r = 0.26$ eV. Hint: Make use of Sec. 6.1.