Homework problems 3

Group III

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Problem No 7.4

Neutron and lepton asymmetry

Making use of the neutrino oscillation results (Appendix C) and the bound (7.13), obtain the bound on neutrino asymmetry in the present Universe defined as

$$\Delta_{L,0} = \frac{\sum_i (n_{\nu_i} - n_{\bar{n}u_i})}{s} ,$$

where s is entropy density. Translate this bound into the bound on lepton asymmetry in the early Universe, whose definition is

$$\Delta_L = \frac{\sum_i n_{L,i}}{s} ,$$

where $n_{L,i} = (n_{\nu_i} - n_{\bar{n}u_i}) + (n_{l_i} - n_{\bar{l}_i})$ is the number density of each lepton flavor and l_i denotes charged leptons, $l_1 = e^-$, $l_2 = \mu^-$, $l_3 = \tau^-$. There are no lepton number violating processes in cosmic plasma.

Problem No 8.4

Neutron burning

Estimate the temperature and age of the Universe at the time when neutron burning terminates. What would be the residual neutron abundance if other reactions were negligible?

Problem 9.11

Free streeming

Let gravitino of mass 100 MeV be dark matter particle, and the mass and lifetime of NLSP be 200 GeV and 10 s. Estimate the present spatial size of density perturbations suppressed as compared to the CDM case (see Sec. 9.1).

Problem 10.5

Higgs vacuum expectation value at high temperatures

Making use of the high-temperature expansion, calculate the values of $\Phi_c(T_{c1})/T_{c1}$ and $\Phi_c(T_{c2})/T_{c2}$ taking into account the contributions of the form (10.28). Check that the results are in better agreement with exact numerical results.