

## Homework problems 3

### Group II

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#### Problem No 7.3

##### Detection of relic neutrinos

Assuming that neutrinos are massless, estimate the mass of a detector required for having one relic neutrino interaction per year.

#### Problem No 8.3

##### Extra types of neutrino

Making use of (8.5)(8.7), (8.13) and (8.24)(8.26) show that every new type of neutrinos gives rise to the correction to primordial helium abundance at the level of 5%.

#### Problem No 9.8

##### Gravitino freeze-out

Find freeze-out temperature of transverse degrees of freedom of gravitino.

#### Problem No 10.3

##### Effective Higgs potential and the critical bubble

Using the expression of Sec. 10.1, find the wall profile of the critical bubble and the surface tension  $\mu$  at temperature close to  $T_{c1}$ . Find the temperature at the which the bubble nucleation rate becomes of the order of the Hubble parameter, i.e. the Universe "boils". What is the ratio of the bubble size and the Hubble length? Find the ratio of the transition latent heat released at this moment to the energy density of particles in the plasma, refining the estimate (10.36). Give numerical estimates for the SM Higgs boson of mass 40 GeV and 125 GeV.