PY3726 Assignment 3

Due: tbd

1. Derive the relations

$$\rho = \frac{\pi^2}{30} g T^4 (BE); \qquad \rho = \frac{7}{8}\frac{\pi^2}{30} g T^4 (FD)$$

$$n = \frac{\zeta(3)}{\pi^2} g T^3 (BE); \qquad n = \frac{3}{4}\frac{\zeta(3)}{\pi^2} g T^3 (FD)$$

for $T >> m, \mu$.

2. Show that

$$n_+ - n_- = 2g \left(\frac{mT}{2\pi}\right)^{3/2} \sinh(\mu/T)\, \mathrm{e}^{-m/T}$$

for $T << m$, where $n_\pm$ represents the chemical potential for a fermion (antifermion).

3. Derive Eq. (4.7) of Kolb and Turner:

$$X_A = g_A[\zeta(3)^{A-1}\pi^2 2^{(3A-5)/2}] A^{5/2} \left(\frac{T}{m_N}\right)^{3(A-1)/2} \eta^{A-1} X_p^Z X_n^{A-Z} \mathrm{e}^{B_a/T}$$

4. Consider BB nucleosynthesis with nuclear species n, p, $\xi(A = 4)$. Obtain expressions for X_n,X_p,X_ξ in terms of η, g_ξ, B_ξ. You may use the standard result for X_n/X_p. Sketch the behaviour of the X's as a function of T^{-1}.