March 24 - B

Determine matter composition
throug minimisation of
energy density @ fixed n_B

$$\epsilon(n_{b_1}, \dots n_{b_B}, n_{\ell_1} \dots n_{\ell_L})$$

with respect to particle densities

Contraints

$$\sum_i n_{b_i} = n_B \qquad \sum_j Q_j n_{b_j} + \sum_i q_i n_{\ell_i} = C$$

Assume npe matter

$$F = \epsilon + \lambda_B (n_B - n_p - n_n) + \lambda_Q (n_p - n_e)$$

$$\frac{\partial F}{\partial n_p} = \frac{\partial F}{\partial n_n} = \frac{\partial F}{\partial n_e} = 0$$

$$\frac{\partial F}{\partial \lambda_B} = \frac{\partial F}{\partial \lambda_Q} = 0$$

introduce chemical

potential

$$\mu_i = \left(\frac{\partial E}{\partial N_i}\right)_{V, N_{j\neq i}}$$

$$= \left(\frac{\partial \epsilon}{\partial n_i}\right)_{V, n_{j\neq i}}$$

$$\mu_p - \lambda_B + \lambda_Q = 0$$

$$\mu_n - \lambda_B = 0$$

$$\mu_e - \lambda_Q = 0$$

$$\mu_p - \mu_n + \mu_e = 0$$

$$\mu_n = \mu_p + \mu_e$$

In general

$$\mu_i = \mu_i(n_i)$$

for any given ρ_B

$$n_p = x\, n_B, \quad n_n = (1-x)\, n_B$$

$$n_e = n_p$$

$$\mu_i = \mu_i(\rho_B, x)$$

For any given baryon density, chemical equilibrium determines the composition of matter

$$\mu_n(\rho_B, x) - \mu_p(\rho_B, x) - \mu_e(\rho_B, x) = 0$$