A bag model of infinite strangeon matter

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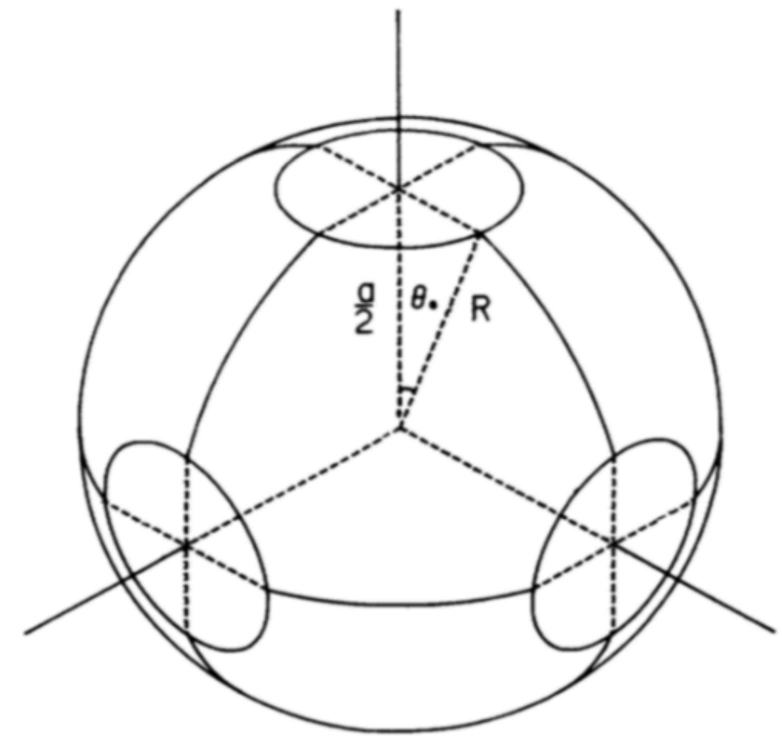
Quarks and Compact Stars 2019
Sep. 27, 2019, Busan

Introduction

The bags in normal nuclear matter may touch each other (depend on the radius of a bag). We assume the nuclear matter to be a bag crystal.

We cut off the overlapping parts and the bags interconnect to compose a huge bag.

Q. R. Zhang, C Derreth, A Schafer and W. Greiner, J. Phys. G 12, L19 (1986)



We generalize this model to describe infinite strangeon matter.

The Model

Energy per baryon

$$E = \sum_i (\Omega_i + N_i \mu_i) + BV - \frac{z_0}{R}\frac{\omega}{4\pi}$$

i --- quark flavor

Total quark number for quark flavor i

$$N_i = n_{i,V}V + n_{i,S}S + n_{i,C}C$$

$n_{i,j}$ --- quark number density

Thermodynamical potential

$$\Omega_i = \Omega_{i,V}V + \Omega_{i,S}S + \Omega_{i,C}C$$

$$\partial\Omega_i/\partial\mu_i = -N_i \quad \partial\Omega_{i,j}/\partial\mu_i = -n_{i,j}$$

$$\begin{aligned}\Omega_{i,V} = -\frac{\mu_i^4}{4\pi^2}\Big(&(1-\lambda_i^2)^{1/2}(1-\frac{5}{2}\lambda_i^2) + \frac{3}{2}\lambda_i^4 \ln[\frac{1+(1-\lambda_i^2)^{1/2}}{\lambda_i}] \\ &-\frac{2\alpha_s}{\pi}(3\{(1-\lambda_i^2)^{1/2} - \lambda_i^2 \ln[1+(1-\lambda_i^2)^{1/2}]\}^2 - 2(1-\lambda_i^2)^2 \\ &- 3\lambda_i^4 \ln^2 \lambda_i + 6 \ln\frac{\rho_R \lambda_i}{m_i}\{\lambda_i^2(1-\lambda_i^2)^{1/2} - \lambda_i^4 \ln[\frac{1+(1-\lambda_i^2)^{1/2}}{\lambda_i}]\}\Big),\end{aligned}$$

$$\begin{aligned}\Omega_{i,S} = \frac{3}{4\pi}\mu_i^3\Big(&\frac{(1-\lambda_i^2)}{6} - \frac{\lambda_i^2(1-\lambda_i)}{3} \\ &- \frac{1}{3\pi}\{\arctan[\frac{(1-\lambda_i^2)^{1/2}}{\lambda_i}] - 2\lambda_i(1-\lambda_i^2)^{1/2} + \lambda_i^3 \ln[\frac{1+(1-\lambda_i^2)^{1/2}}{\lambda_i}]\}\Big),\end{aligned}$$

$$\Omega_{i,C} = \frac{\mu_i^2}{8\pi^2}\Big(\lambda_i^2 \ln[\frac{1+(1-\lambda_i^2)^{1/2}}{\lambda_i}] + \frac{\pi}{2\lambda_i} - \frac{3\pi\lambda_i}{2} + \pi\lambda_i^2 - \frac{1}{\lambda_i}\arctan[\frac{(1-\lambda_i^2)^{1/2}}{\lambda_i}]\Big),$$

$$\lambda_i \equiv m_i/\mu_i.$$

$$E = \sum_i (\Omega_i + N_i \mu_i) + BV - \frac{z_0}{R}\frac{\omega}{4\pi}$$

Parameterization of bag constant

$$B = B_0 + k(\sum_i \mu_i - 938)^2 \qquad \text{with } B_0 = 60 \text{ MeV fm}^{-3},\ k = \frac{1}{50^2} \text{ MeV}^{-1} \text{ fm}^{-3}$$

Fitting z0 in nuclear matter

At fixed ρ and α_s , we fix z0 by letting the minimum energy per baryon equal to

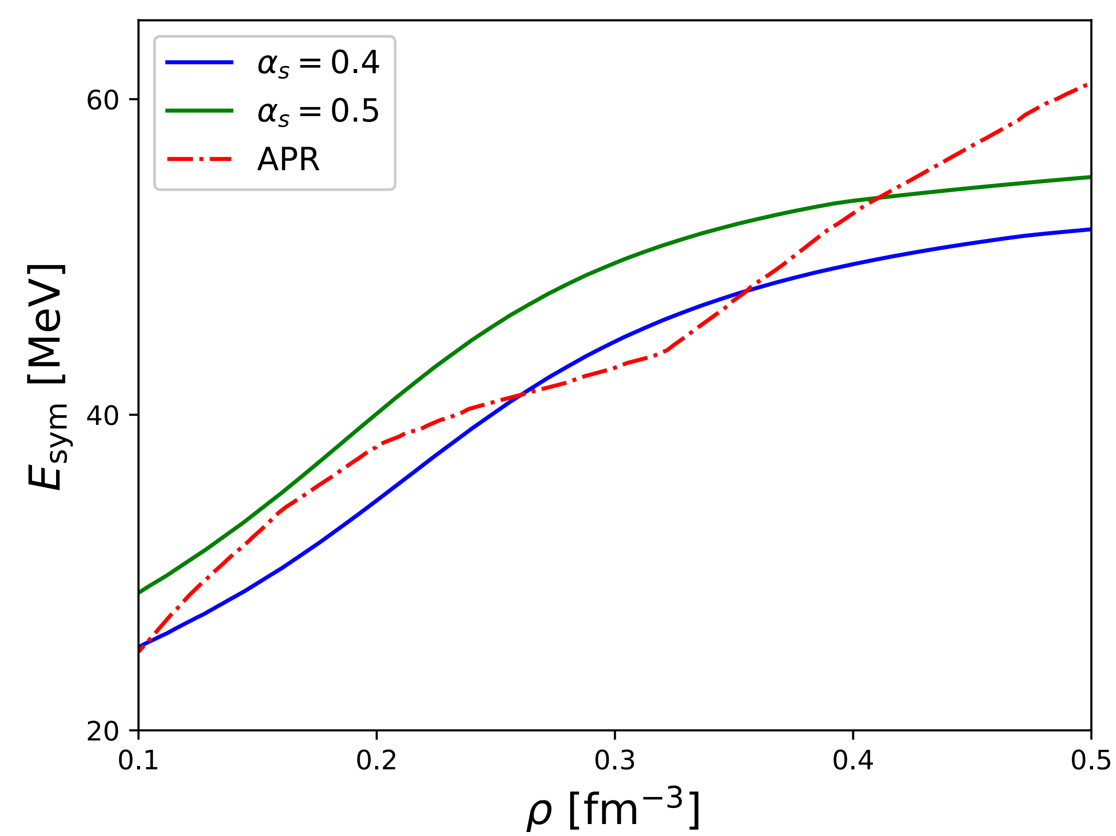
$$E_0(\rho) = E_0(\rho_0) + \frac{K_0}{2}(\frac{\rho - \rho_0}{3\rho_0})^2$$

$$\rho_0 \approx 0.16 \text{ fm}^{-3} \qquad K_0 = 240 \pm 20 \text{ MeV}$$

Once we get z0, we can calculate the symmetry energy at various density.

Table.1 The obtained parameters at saturation density ρ_0.

α_s	B/MeV fm^{-3}	z_0	$\theta/°$	E_{sym}/MeV
0	61.4	1.907	29.09	18.35
0.1	62.8	2.172	29.09	20.54
0.2	65.0	2.49	29.00	23.18
0.3	68.6	2.86	28.60	26.37
0.4	74.4	3.32	27.89	30.27
0.5	83.7	3.87	26.71	35.04



Generalization to strangeon matter

We simply generalize the bag constant and zero point constant in nuclear matter to strangeon matter.