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Onset of free hyperons in neutron stars from LOCV

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lOCV(the lowest-order constrained variational method)

$$E[f] = \frac{1}{A}\frac{\langle\Psi|H|\Psi\rangle}{\langle\Psi|\Psi\rangle} = E_1 + E_{MB} \cong E_1 + E_2$$

Jasrow approximation

$$\Psi\ (1\cdots A) = f\ (1\cdots A)\Phi\ (1\cdots A) \quad \&$$

$$f\ (1\cdots A) = \prod_{i>j} f\ (ij)$$

$$f\ (ij) = \sum_{\alpha,p=1}^{3} f_\alpha^p(ij)\, O_\alpha^p(ij)$$

There is 3 correlation functions in LOCV method

$$\begin{cases} p = 1\ for \begin{cases} s = 0 \\ s = 1\ with\ L = J \end{cases} \\ p = 2,3\ for\ s = 1\ with\ J = L \pm 1 \end{cases}$$

$$\alpha = \{J, L, S, T, T_z\}$$

$$O_\alpha^{p=1-3} = 1, \left(\frac{2}{3} + \frac{1}{6}S_{12}\right), \left(\frac{1}{3} - \frac{1}{6}S_{12}\right)$$

Energy of two-body clusters → $$E_2 = \frac{1}{2A}\sum_{ij}\langle ij|W\ (12)|ij - ji\rangle$$

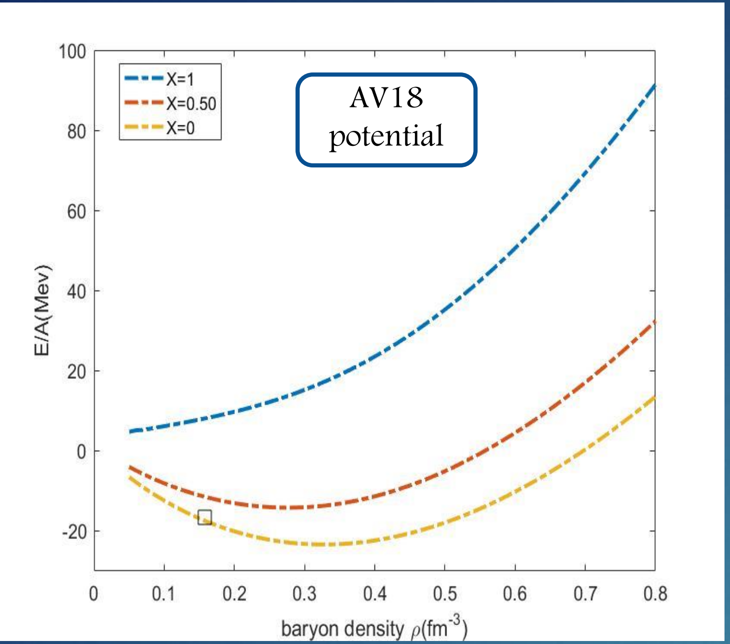
Effective interaction → $$W\ (12) = -\frac{\hbar^2}{2m}\left[f\ (12), [\nabla_{12}^2, f\ (12)]\right] + f\ (12)v(12)f\ (12)$$

Normalization condition $$\langle\Psi|\Psi\rangle = 1 - \sum_{ij}\langle ij|f^2|ij - ji\rangle$$

Constraint $$\chi = \frac{1}{A}\sum_{ij}\left\langle ij\middle|f_P{}^2 - f^2\middle|ij - ji\right\rangle = 0$$

$$\delta E_2 = \int dr\left[G\left(f'^2(r)\right) + S(f(r)) - \lambda(f(r))\right] = \int dr\, L(f'(r), f(r)) = 0 \longrightarrow \frac{d}{dr}\left[\frac{\partial L}{\partial f'}\right] - \frac{\partial L}{\partial f'} = 0$$

By solving this equation we have EOS and every related parameter

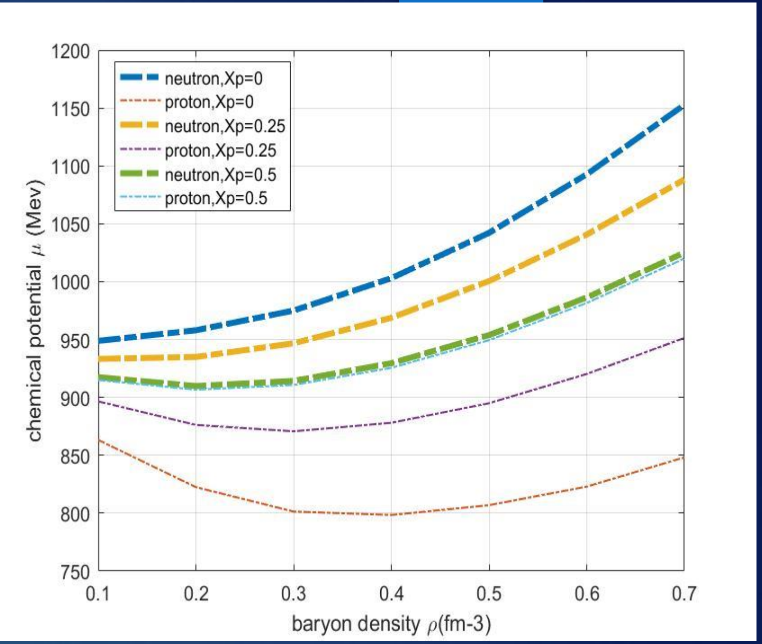


$$\mu_l = \left(\hbar^2 c^2 k_f^2 + m_l^2 c^4\right)^{\frac{1}{2}}$$

free hyperon : $\mu_Y = m_Y c^2 + \varepsilon_f = m_Y c^2 + \dfrac{\hbar^2 c^2 k_f^2}{2 m_Y c^2}$

$$\mu_n(\rho, x) = \frac{\partial E}{\partial N_n} = \frac{E(\rho, x)}{A} + \left[\rho \frac{\partial}{\partial \rho} - x \frac{\partial}{\partial x}\right] \frac{E(\rho, x)}{A}$$

$$\mu_p(\rho, x) = \frac{\partial E}{\partial N_p} = \frac{E(\rho, x)}{A} + \left[\rho \frac{\partial}{\partial \rho} + (1 - x) \frac{\partial}{\partial x}\right] \frac{E(\rho, x)}{A}$$



Beta stable condition:

$$\mu_i = b_i \mu_n - q_i (\mu_l - \mu_{\nu_l})$$

$$\mu_p = \mu_n - \mu_e$$

$$\mu_e = \mu_{\mu^-}$$

$$\mu_{\Sigma^-} = \mu_n + \mu_e = 2\mu_n - \mu_p$$

$$\mu_\Lambda = \mu_n$$

$$\boldsymbol{\rho_p = \rho_e + \rho_{\mu^-} + \rho_{\Sigma^-}}$$

$$\boldsymbol{\rho_b = \rho_n + \rho_p + \rho_{\Sigma^-} + \rho_\Lambda}$$