Quark condensate and chiral symmetry restoration in neutron stars

Methodology

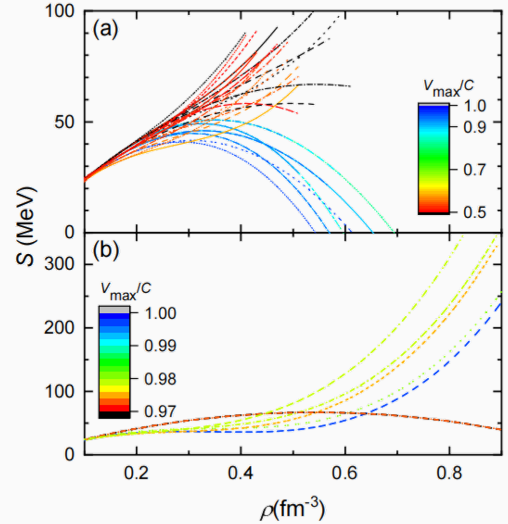
Taylor expansion

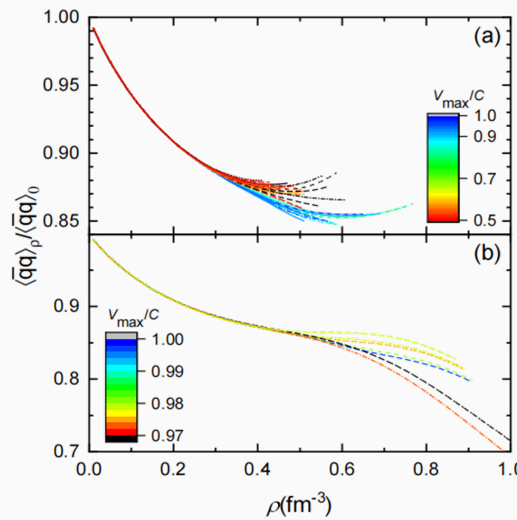
$$\epsilon_0(\rho) = \epsilon_0(\rho_0) + \frac{K}{18}\left(\frac{\rho}{\rho_0} - 1\right)^2 + \frac{J}{162}\left(\frac{\rho}{\rho_0} - 1\right)^3$$

$$S(\rho) = S(\rho_0) + \frac{L}{3}\left(\frac{\rho}{\rho_0} - 1\right) + \frac{K_{sym}}{18}\left(\frac{\rho}{\rho_0} - 1\right)^2 + \frac{J_{sym}}{162}\left(\frac{\rho}{\rho_0} - 1\right)^3$$

Equivparticle model

$$\frac{\langle\bar{q}q\rangle_\rho}{\langle\bar{q}q\rangle_0} = 1 - \frac{1}{3n}\frac{E_I}{m_I}$$





Results

I. The symmetry energy at large densities are consistent with various constraints from heavy-ion collisions , which may even become negative at $\rho \gtrsim 3\rho_0$ if the constraints are limited to $\rho < \rho_{1.4}$.

II. Throughout the density range of neutron stars ($\rho \leq \rho_{TOV}$), the constrained quark condensate does not vanish.