Hypernuclei and nuclear matter in a RMF model with chiral SU(3) potential

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In constructing the dense matter equation of state (EOS), it is desired to respect both chiral symmetry and hypernuclear physics. In dense matter, strangeness is expected to play a decisive role and the partial restoration of chiral symmetry would modify the hadron properties.

For chiral symmetry side, we have recently developed a chiral SU(2) symmetric RMF model \cite{1} with logarithmic sigma potential in the form of $- \log \sigma$, which is derived in the strong coupling limit (SCL) of the lattice QCD \cite{2}. In this model, the energy density in vacuum at zero temperature is evaluated as,

$$U = -a \log(\det MM^\dagger) + \frac{b}{2} \text{tr}(MM^\dagger) - c \sigma \sim -a \log \sigma + \frac{b}{2} \sigma^2 - c \sigma$$

where $M$ denotes the SU(2) meson matrix, $M = (\sigma + i \tau \cdot \tau)/\sqrt{2}$. In this SCL model, we can describe not only symmetric nuclear matter but also bulk properties of finite nuclei.

On the other hand, from a viewpoint of hypernuclear physics, we develop an extended chiral SU(3) RMF model which include both of chiral symmetry and hypernuclear physics informations \cite{3}. We determine the hyperon-meson coupling constants in this chiral SU(3) RMF model by fitting existing data. We can reproduce the separation energies of single hypernuclei ($S_{\Lambda}$) and the $\Lambda \Lambda$ bond energy ($\Delta B_{\Lambda \Lambda}$) in $^6\Lambda\Lambda$He by choosing the coupling constants appropriately in a reasonable parameter range. The EOS of symmetric matter is found to be softened by the scalar meson with hidden strangeness, $\zeta = \bar{s}s$, which couples with $\sigma$ through the determinant interaction.

In this presentation, we present this RMF model including chiral SU(3) potential and its results. In addition, we discuss nuclear star in this chiral SU(3) RMF model and show an effect to nuclear star maximum mass by introducing this potential.

References

