η mesons in hot and dense matter

Rajesh Kumar and Arvind Kumar
Department of Physics, NIT Jalandhar

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ηB Lagrangian Density in Chiral SU(3) model

$$\begin{aligned}\mathcal{L}_{\eta B} &= \left(\frac{1}{2} - \frac{\sigma' + 4\zeta'(2f_K - f_\pi)}{\sqrt{2}f^2}\right)\partial^\mu\eta\partial_\mu\eta \\ &- \frac{1}{2}\left(m_\eta^2 - \frac{(\sqrt{2}\sigma' - 4\zeta')m_\pi^2 f_\pi + 8\zeta' m_K^2 f_K}{\sqrt{2}f^2}\right)\eta^2 \\ &+ \frac{1}{4f^2}\left(d'\sum_i \rho_i^s + 2d_2\rho_{\Lambda_0}^s\right)\partial^\mu\eta\partial_\mu\eta.\end{aligned}$$

Equation of Motion

$$\begin{aligned}&\partial^\mu\partial_\mu\eta - \left(m_\eta^2 - \frac{(\sqrt{2}\sigma' - 4\zeta')m_\pi^2 f_\pi + 8\zeta' m_k^2 f_k}{\sqrt{2}f^2}\right)\eta \\ &+ \frac{2}{f^2}\left(\frac{d'\rho_B^s}{4} + \frac{d_2\rho_{\Lambda_0}^s}{2} - \frac{\sigma' + 4\zeta'(2f_K - f_\pi)}{\sqrt{2}}\right)\partial^\mu\partial_\mu\eta = 0.\end{aligned}$$

with $f = \sqrt{f_\pi^2 + 2(2f_K - f_\pi)^2}$.

- Dispersion Relation

$$-\omega^2 + \vec{k}^2 + m_\eta^2 - \Pi^*(\omega, |\vec{k}|) = 0,$$

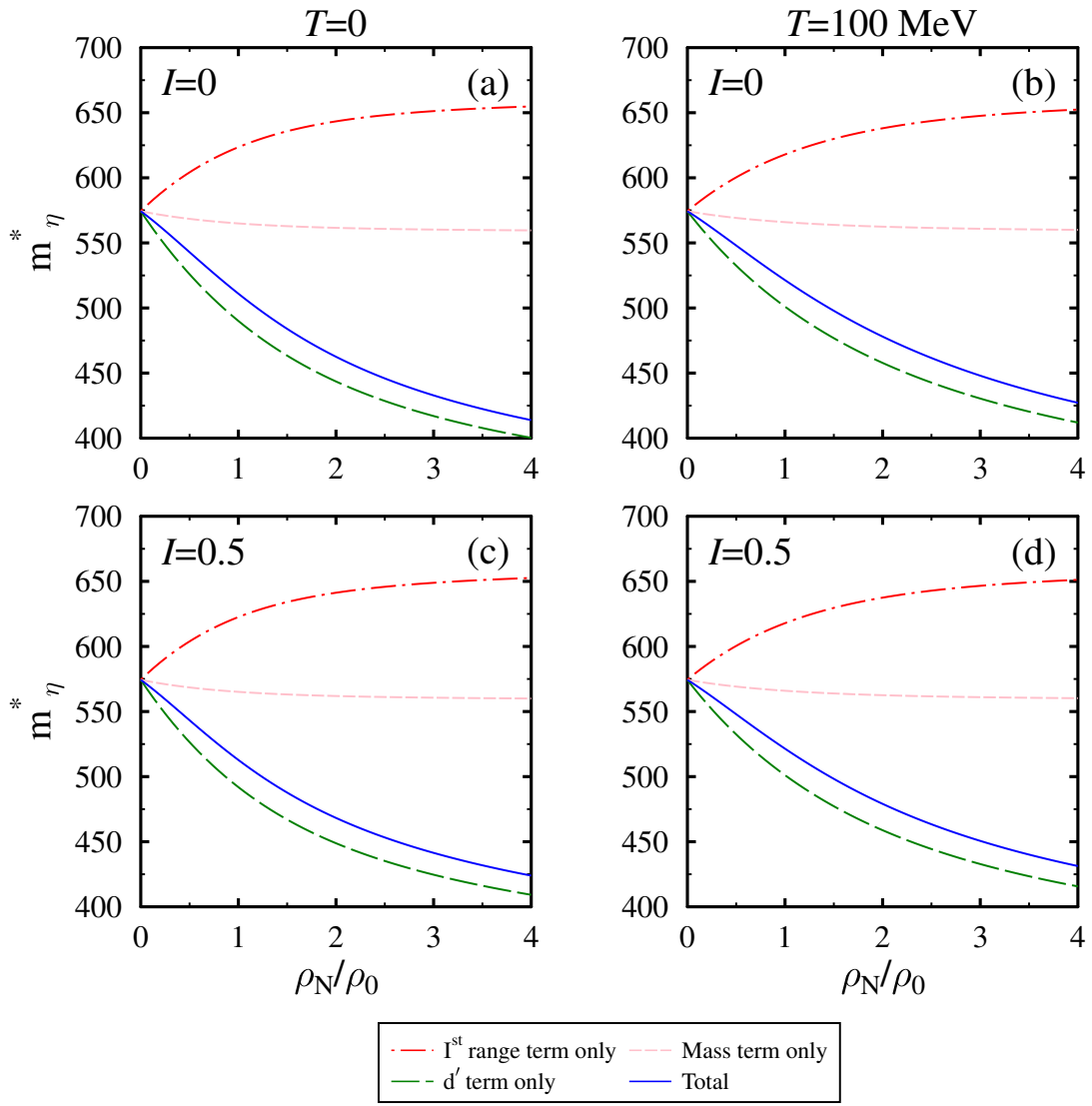
The Π^* denotes the in-medium self-energy of η meson

$$\begin{aligned}\Pi^*(\omega, |\vec{k}|) &= -\frac{(\sqrt{2}\sigma' - 4\zeta')m_\pi^2 f_\pi + 8\zeta' m_K^2 f_K}{\sqrt{2}f^2} + \frac{2d'}{f^2}\left(\frac{d'\rho_B^s}{4} + \frac{d_2\rho_{\Lambda_0}^s}{2}\right) \\ &- \frac{2}{f^2}\left(\frac{\sigma' + 4\zeta'(2f_K - f_\pi)}{\sqrt{2}}\right)(\omega^2 - \vec{k}^2).\end{aligned}$$

- Momentum dependent optical potential

$$U_\eta^*(\omega,\ \mathbf{k}) = \omega(\mathbf{k}) - \sqrt{\mathbf{k}^2 + m_\eta^2}.$$

Contribution of $\mathcal{L}_{\eta\mathcal{B}}$ Different Terms at $\rho_{Hyperons} = 0$



Comparison with Existing Literature

Framework	U_η^*(MeV)
Chiral model, strange matter	-59.41
Chiral Model, only nucleons [5]	-46.18
ChPT + Chiral Model [5]	-116.83
Chiral Unitary Approach [1]	-34
Coupled Channel [2]	-54
QMC Model [3]	-60
Chiral Perturbation Theory (ChPT) + Relativistic Mean-field Model [4]	-83

Table: In-medium optical potential at zero momentum and $\rho_B = \rho_0$.

References

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