PAULI BLOCKING EFFECT WITHIN THE RELATIVISTIC PION GAS*

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We show that the Φ-derivable formulation of the cluster virial expansion for quark–meson matter contains the quark Pauli blocking effect in a pion gas in the lowest order expansion with respect to the backreaction of pions on the quark dynamics.

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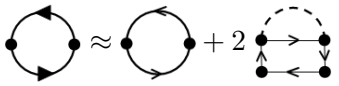
In the Φ-derivable approach [1] for the cluster virial expansion for quark-meson matter, the thermodynamic potential reads [2]

$$\Omega = \mathrm{Tr}\left\{-\ln S_q^{-1} - \Sigma_q S_q + \tfrac{1}{2}\ln D_\pi^{-1} + \tfrac{1}{2} D_\pi \Pi_\pi\right\} + \Phi[S_q, D_\pi], \Phi[S_q, D_\pi] =$$  .

The Φ functional is a 2PI skeleton diagram with dressed quark and pion propagators that fulfill the Dyson–Schwinger equations $S_q^{-1} = S_{q,\mathrm{MF}}^{-1} - \Sigma_q$ and $D_\pi^{-1} = G_\pi^{-1} - \Pi_\pi$, respectively. The self-consistent mean-field propagator is $S_{q,\mathrm{MF}} = [\not{p} - m_0 - \Sigma_{q,\mathrm{MF}}]^{-1}$ with the Hartree self-energy $\Sigma_{q,\mathrm{MF}}$ and the coupling constant $G_\pi = 2G_S$ being determined within the PNJL model. The self-energies of quarks and pions are obtained by a functional derivative from the Φ functional

$$\Sigma_q = \frac{\delta\Phi}{\delta S_q} =$$  (1)

$$\Pi_\pi = \frac{\delta\Phi}{\delta D_\pi} =$$  (2)

A fully self-consistent solution of the above thermodynamic potential would include the backreaction of pions in the medium on the propagation of

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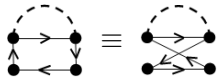
quarks [3] which is not present in the traditional rainbow-ladder scheme [4]. A first step towards a self-consistent solution is to expand the quark propagator in first order of the self-energy Σ_q

$$S_q = S_{q,\mathrm{MF}} + S_{q,\mathrm{MF}} \Sigma_q S_{q,\mathrm{MF}} + \mathcal{O}\left(\Sigma_q^2\right) . \tag{3}$$

Inserting the expansion (3) into the pion self-energy (2) and dropping terms of $\mathcal{O}(\Sigma_q^2)$, one obtains the rightmost diagram in (2) as a contribution to the pion self-energy. This term corresponds to the pion self-energy resulting from the quark box diagram in the NJL model description of $\pi\pi$ scattering [5], see also [6]. It is topologically equivalent to the quark exchange contribution in the meson–meson scattering [7,8]



(4)

which results in an excellent description of the repulsive isospin 2 phase shift δ_0^2 of the $\pi\pi$ scattering which is very important for the phenomenology of hadron resonance gases since it approximately cancels the contribution from the broad σ meson resonance in the δ_0^0 channel [9,10].

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