Realistic Kaon-Nucleon Interaction and Kaon Condensation

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Recently, the antikaon-nucleon scattering has been studied in the framework of the relativistic chiral SU(3) Lagrangian imposing constraints from the K^+-nucleon and pion-nucleon sector [1]. The covariant coupled-channel Bethe-Salpeter equation has been solved with the interaction kernel truncated to the third chiral order including the terms which are leading in the large N_c limit of QCD. All SU(3) symmetry-breaking effects are well under control by combined chiral and large N_c expansion. The kaon-nucleon and antikaon-nucleon scattering amplitudes from [1] obey not only dispersion relations but also crossing symmetry. Therefore the antikaon-nucleon scattering amplitude remains physically constrained even below threshold.
This analysis gives an opportunity to extend results of [2,3] taking into account off-pole (regular background) contributions to the kaon self-energy. Also accurate fit of the experimental data achieved in [1] fixed the values of the kaon-nucleon-hyperon coupling constants. Particularly, the $\Sigma^*(1385)$-pole contribution to the kaon-nucleon scattering was proved to be sizable, being not included in [2,4].
We use this scattering amplitude to construct the kaon polarization operator in dense baryonic matter of arbitrary isotopic composition including s- and p-wave kaon-baryon interactions. Contributions of the $\Lambda(1116)$, $\Sigma(1195)$, $\Sigma^*(1385)$ resonances are taken explicitly into account in the pole and regular terms with inclusion of mean-field potentials. Short-range baryon-baryon correlations are incorporated and the corresponding correlation parameters are estimated. Results are applied for K^- in neutron star matter. Within our model the second order phase transition to the s-wave K^- condensate occurs at $\rho_c \gtrsim 4\rho_0$ (with the correlations included). We show that the second order phase transition to the p-wave K^- condensate may occur at a smaller density.

References

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