Kaonic Modes in Hyperonic Matter and Kaon Condensation in Neutron Stars

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Possible existence of kaon condensation has been providing new aspects of high-density hadronic matter. Recently, it has also been suggested based on the development of hypernulear experiments that hyperons may be mixed as well as neutrons, protons, and leptons in neutron-star matter (hyperonic matter). The existence regions of these phases may overlap each other. Here we discuss the interplay between kaon condensation and hyperons by considering the kaon dispersion relations in hyperonic matter. We take into account the kaon-baryon interactions by the use of the effective chiral Lagrangian, which includes both s-wave and p-wave interactions. The potential energy contributions V_i ($i = p, n$, Λ, Σ^-, Ξ^-) are also taken into account through the nonrelativistic potential energy density. The form factor F is introduced at the kaon-baryon vertices as $F = (\Lambda^2 - m_K^2)/(\Lambda^2 + \mathbf{k}^2)$, where Λ is a cut-off factor, m_K the kaon mass, and $\mathbf{k}$ the kaon momentum.

It has been shown that there appears an instability with respect to a pair creation of collective particle-hole modes which have K^+ and K^- quantum numbers ($[p\Lambda^{-1}]$ and $[\Xi^-\Lambda^{-1}]$), stemming from the p-wave kaon-baryon interaction (p-wave kaon condensation) [1]. In Fig. 1, the dispersion relations for kaonic modes are shown for Λ=1200 MeV and for the baryon number density $\rho_{\rm B}$=0.68 fm^{-3} just above the critical density $\rho_{\rm B}^C$. As seen in Fig. 1, the instability occurs at $|\mathbf{k}| \sim 60$ MeV. The value of $\rho_{\rm B}^C$ is shown to be comparable to or lower than that for the conventional s-wave K^- condensation depending on the extent of suppression of the p-wave attraction due to F. In Fig. 2, we show the equation of state including a transition of a hyperonic matter to the p-wave kaon-condensed phase. We also dicuss the internal structure and cooling properties of neutron stars.

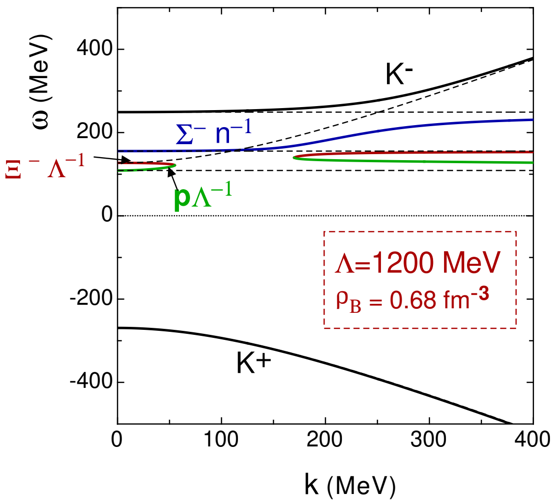

FIG. 1.

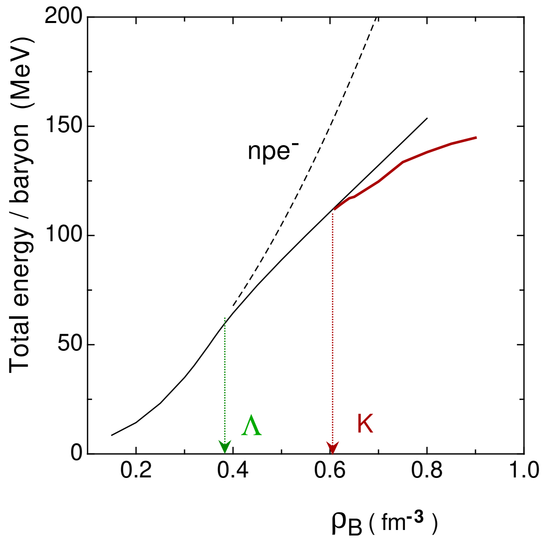

FIG. 2.

References [1] T. Muto, Nucl. Phys. **A697** (2002) 225.