PHASE DIAGRAM OF THE THREE-FLAVOR COLOR SUPERCONDUCTING PNJL MODEL*

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The phase diagram of the color superconducting three-flavor Polyakov-loop extended Nambu–Jona-Lasinio model is analyzed for symmetric matter with a parametrization consistent with the $2M_\odot$ mass constraint from the pulsars PSR J1614-2230 and PSR J0348+0432. The relevance of the result for heavy-ion collisions in the NICA/FAIR energy range is discussed.

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The phase diagram (PhD) of quantum chromodynamics (QCD) is an object of intensive study at already existing heavy-ion collision facilities (LHC, RHIC, SPS) and will also be investigated at the planned ones (FAIR, NICA). Since lattice simulations at finite chemical potential suffer from the sign problem, effective low-energy QCD models of the Nambu–Jona-Lasinio (NJL) type have been applied in order to predict the phase structure of QCD at high densities. NJL models extended by the Polyakov-loop have been shown to reproduce well lattice results at $\mu = 0$ when normalized to their pseudocritical temperature $T_{\rm c}$. The absolute value of $T_{\rm c}$ does not agree with the lattice QCD result for local PNJL models but agrees fairly well for nonlocal ones [1]. In this report, we extend the study of 2-flavor quark matter [2] taking into account the constraints on the model parameters following from mass measurements of PSR J1614-2230 [3] and PSR J0348+0432 [4] (for details, see [5]). By solving the gap equations for the order parameters related to symmetries and their breaking in the color superconducting three-flavor PNJL model [6] as functions of temperature T and baryochemical potential μ, one arrives at a PhD with three order parameters characterizing the phase structure: the chiral condensate, the diquark gap and the Polyakov loop.

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The phase diagram of the 3FCS PNJL model for symmetric quark matter is presented in Fig. 1 without (left panel) and with (right panel) the assumption of a universal hadronisation pressure $P_{\rm crit} \sim 80 \pm 3$ MeV/fm^3 [7]. The entropy per baryon isolines indicate paths for the dynamical evolution of a fireball at NICA/FAIR energies (left panel). The region of thermodynamic instability of homogeneous quark matter ($n_B < 0$) is excluded by defining the hadronic phase with non-negative pressure below $P_{\rm crit}$. We emphasize the accessibility at NICA/FAIR energies of a "quarkyonic matter" region with partial chiral symmetry restoration inside the hadronic world, as well as a quadruple point (black square) where the four phases meet [8,9].

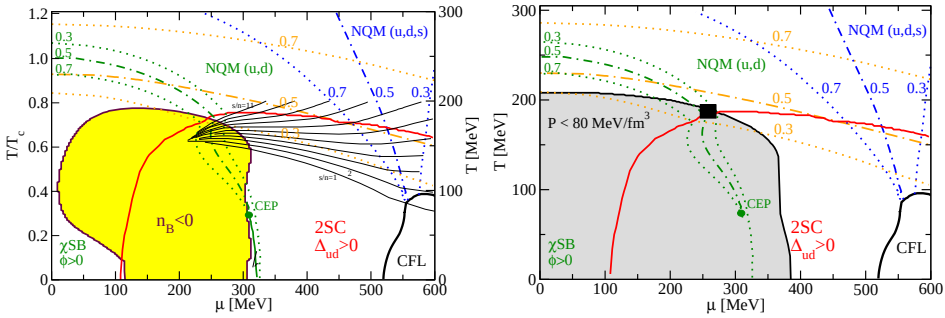

Fig. 1. Phase diagram of the 3FCS PNJL model for symmetric quark matter.

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