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Early onset of color-superconducting quark matter in neutron stars

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We present a relativistic density functional approach to color superconducting quark matter that mimics quark confinement by a fast growth of the quasiparticle self-energy in the confining region. The approach is shown to be equivalent to a chiral model of quark matter with medium dependent couplings. The approach to the conformal limit at asymptotically high densities is provided by a medium dependence of the vector-isoscalar, vector-isovector and diquark couplings motivated by non-perturbative gluon exchange [2]. While the (pseudo)scalar, vector-isoscalar and vector-isovector sectors of the model are fitted to the mesonic mass spectrum and vacuum phenomenology of QCD, the strength of interaction in the diquark channel is varied in order to obtain the best agreement with the observational constraints from measurements of mass, radius and tidal deformability of neutron stars. These constraints favor an early onset of deconfinement and color superconductivity in neutron stars with masses below one solar mass. We also discuss a new two-zone interpolation scheme for the construction of the hadron-to-quark matter transition [3] that allows to test different structures of the QCD phase diagram with one, two or no critical endpoints in simulations of supernova explosions, neutron star mergers and heavy-ion collisions. I argue that the formation of color-superconducting quark matter drives the trajectories of its evolution in supernovae and neutron star mergers towards the regimes reached in terrestrial experiments with relativistic heavy ion collisions.

[1] O. Ivanytskyi and D. Blaschke, Phys. Rev. D 105, 114042 (2022)
[2] O. Ivanytskyi and D. Blaschke, Particles 5, 514 (2022)
[3] O. Ivanytskyi and D. Blaschke, Eur. Phys. J A. 58, 152 (2022

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