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Extended Nambu–Jona-Lasinio model for quark and nuclear matters

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In this work, we extend the two-flavor Nambu–Jona-Lasinio model to one capable of exploring quark and nuclear matter consistently. With an extra term standing for quark-nucleon interactions, nucleons could automatically emerge as color-singlet three-quark entities by following a process similar to mesons. Besides the quark part in mean field approximation, both mesons and nucleons could contribute to the thermodynamic potential thus possibly give rise to quarkyonic matter beyond mean field. In the study, two kinds of "confining" couplings are adopted for the new interaction term and two different quark masses are considered for comparison. It turns out that only confined nuclear matter or deconfined quark matter is possible for all the cases at zero temperature, thus quarkyonic matter is not favored at all. Even more strictly, only the case with stronger confinement effect and a smaller quark mass admits a physical first-order phase transition from nuclear matter to quark matter around twice saturation density.

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