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3-flavor extension of the excluded volume model for the hard-core repulsion

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There are many motivations to study the phase structure of quantum chromodynamics (QCD), related to investigations of relativistic heavy-ion collisions, early universe, and compact stars. Moreover, the QCD phase diagram remains poorly understood, despite all the efforts dedicated to its description over the years, due to the difficulty of first principle calculations and the lack of experimental observation in the region of intermediate and high baryon densities. On the other hand, recent observations of 2-solar mass neutron star and gravitational waves from neutron star inspiral have been providing important insights about the equation of state (EoS) of dense matter. To support such a massive state, and the radius inferred from the observed tidal deformability from the inspiral, sound velocity can be greater than its conformal value, $c_s^2 \leq 1/3$, for densities few times of the nuclear matter densities. One of the alternatives that can take into account this anticipation is the quarkyonic-like model, where the repulsive enough nuclear interaction makes the EoS stiff and the dynamically generated quark degrees of freedom make the stiffness moderate after the onset density. In this work, we suggest a model of hard core nucleon interactions in an excluded volume, particularly suitable for the description of the three flavor quarkyonic matter. In this model, the nucleonic shell has a density related to the size of the hard core and becomes thinner as the density increases, and eventually, the quark degrees of freedom dominates. We study how the strangeness affects the equation of state, the behavior of the sound velocity and verify if the results are in agreement with neutron stars observations.

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