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Momentum shell and rapid stiffening in Quarkyonic matter from explicit duality

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Large-N_c QCD implies a duality between confined baryons and deconfined quarks at high baryon densities; it is called Quarkyonic matter. We present a model of Quarkyonic matter that is explicitly dual between quarks and baryons. The duality means that the free energy of the matter is expressed in two ways: One is as a functional of the quark distribution function in the momentum space, f_Q, and the other as a functional of the baryon distribution function, f_B. We then posit the duality relation between f_Q and f_B, which describes the binding of quarks into baryons.
We explicitly construct an analytic solution of this model and show that the theory has two distinct regimes: An ordinary nuclear matter regime at low density and a Quarkyonic regime at relatively high density. In the Quarkyonic regime, f_B is underoccupied at low momentum and has an enhanced occupation at high momentum, which can be interpreted as that baryons sit on a shell in momentum space on top of a quark Fermi sea. Baryons and quarks do not interact except for the duality relation and the constraint that f_Q and f_B must satisfy $0 \leq f_Q \leq 1$ and $0 \leq f_B \leq 1$. Such a theory describes a rapid transition from a soft nuclear equation of state to a stiff Quarkyonic equation of state. At this transition, there is a rapid increase in the sound velocity.

Category

Theory

Collaboration (if applicable)

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