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Suppression of the repulsive force in nuclear interactions near the chiral phase transition

One of the issues in hot/dense QCD is to understand the state of matter in the vicinity of phase transition from hadronic matter to quark matter expected to be created in heavy-ion collisions, or to be present in the interior of compact stars.
In nuclear physics, a scalar meson plays an essential role as known from Walecka model that works fairly well for phenomena near nuclear matter density. On the other hand, at high density, the relevant Lagrangian that has correct symmetry is the linear sigma model, and the scalar needed there is the sigma that is the fourth component of the chiral four-vector. Thus in order to probe highly hot/dense matter, we have to figure out how the chiral scalar at low temperature/density transmutes to the fourth component of the four-vector.

In this talk, we introduce a chiral scalar as a dilaton associated with broken conformal symmetry and responsible for the trace anomaly of QCD and discuss the properties of nuclear matter at high density [1]. As the "dilaton limit" is taken, which drives a system from nuclear matter density to near chiral restoration density, a linear sigma model emerges from the highly nonlinear structure with the omega meson decoupling from the nucleons.
A striking prediction of this procedure is that as the dilaton limit is approached as density increases, the omega-nucleon interaction known to be repulsive at low density gets strongly suppressed at high density. The omega-mediated short-range repulsion gets also suppressed. This occurs in the rho-meson exchanged repulsion too. Consequently the symmetry energy which plays a crucial role in the structure of compact stars gets suppressed. An immediate consequence would be that the equation of state (EoS) of dense matter will be softened at high density and would accommodate the EoS without any exotica consistent with the recent measurement of a 2-solar-mass neutron star.

Reference:
[1] Chihiro Sasaki, Hyun Kyu Lee, Won-Gi Paeng and Mannque Rho,
"Conformal anomaly and the vector coupling in dense matter,"
arXiv:1103.0184 [hep-ph].

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