NewCompStar STSM scientific report

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STSM topic: A baryon-quark model and its application to extreme densities

Host: Prof. Igor Mishustin

The purpose of this STSM was the construction of a baryon-quark effective model. Such a model is needed for the investigation of the QCD phase transitions at large density, which can occur in compact stars and in the future heavy ion collisions at FAIR and NICA. While the vast majority of models of high density QCD treat nuclear matter and quark matter separately, the main goal was to find a simple framework that is able to include both nucleons and quarks in a single framework.

During the STSM I have collaborated with Prof. Igor Mishustin and Dr. Chihiro Sasaki from FIAS. We carried out the following work. We constructed a unified nuclear-quark-meson model that satisfies the following properties:

1. Chiral and scale symmetry,
2. single bosonic vacuum potential for both nucleons and quarks,
3. suppression of quarks at low density and suppression of nucleons at high density,
4. nuclear matter ground state,
5. asymptotic freedom.

In order to have properties 1. and 2. we have used the parity doublet model for nuclear matter and the quark-meson model for quark matter. We have found that an effective way to have property 3. is to modify the distribution functions of both nucleons and quarks. We have considered this modification in a self-consistent framework by introducing an auxiliary bosonic field to controls the onset of the nuclear and the quark degrees of freedom. We have calculated the ground state of the model at a given density by minimizing the thermodynamic potential in the mean-field approximation.

The main result of this STSM is a successful treatment of both nuclear and quark degrees of freedom in a single framework. Further results are that the model has separate chiral and deconfinement phase transitions. We have found that both of these phase transitions are first order, and that in particular the deconfinement phase transition proceeds with a large jump in the density.

We believe that the constructed model is simple but rather complete, and therefore it can be used for further applications. We foresee a publication of two scientific papers as a direct result of this STSM.