

Dualities and pion condensation in dense hadron/quark matter

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In this talk the phase structure of the dense quark matter has been investigated in the presence of baryon μ_B , isospin μ_I , chiral μ_5 and chiral isospin μ_{I5} chemical potentials in the framework of Nambu–Jona-Lasinio model. It has been shown that in the large- N_c limit (N_c is the number of colors of quarks) there exist duality correspondences (symmetries) at the phase portrait, which are the symmetries of the thermodynamic potential and the phase structure itself. The first one is a duality (symmetry) between the chiral symmetry breaking and the charged pion condensation phenomena. And there are two other dualities that hold only for chiral symmetry breaking and charged pion condensation phenomena separately. For example, we have shown that charged pion condensation does not feel the difference between chiral and isospin imbalances of the medium. The duality between the chiral symmetry breaking and the charged pion condensation phases has been established for the first time in low-dimensional toy model for QCD, then it has been checked to take place in a more realistic effective model for QCD. They were shown to exist in the matter with chiral imbalance that can be produced in compact stars or heavy ion collisions. One of the key conclusions of these studies is the fact that chiral imbalance generates charged pion condensation in dense baryonic/quark matter.

It is known that chiral imbalance can occur in high energy experiments of the collision of heavy ions, due to temperature and sphaleron transitions. Our studies show that different types of chiral imbalance can occur in the cores of neutron stars or in heavy ion experiments, where large baryon densities can be reached, due to another phenomena - the so-called chiral separation and chiral vortical effects.