Chiral Condensation and Color Superconductivity in Strangelet

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Chiral symmetry breaking (χSB) and color superconductivity (CSC) in a finite size strangelet are investigated within the three flavor NJL model. We postulate that the strangelet has a spherical shape, subject to the boundary condition of the MIT bag model. The dynamically generated quark mass and gap in the strangelet are investigated at finite densities.

χSB and CSC are characteristic phases in the quark matter. χSB is caused by attractive interaction between a $q\bar{q}$ pair and realized at low densities, while CSC is caused by attractive interaction between a qq pair and expected to be seen at high densities. While χSB is considered to happen in our low density world, CSC is not confirmed yet. There are conjectures that CSC is formed in neutron stars and/or in quark stars. However it is very difficult to observe it directly in laboratories.

A very interesting possibility has been discussed to observe CSC in the strangelets. Strangelets are compact objects of quark matter composed of u, d and s quarks [1], [2]. They are possibly generated through collapses and explosions of neutron stars or have survived since the early universe. There are several massive particles observed in cosmic rays which may be candidates for strangelets.

There are several theoretical works investigating χSB [3] and CSC [4] in the NJL model for a finite system. In our work we introduce quarks in a spherical MIT bag in order to treat a confined quark system, and use the NJL lagrangian in order to describe the important quark interactions for χSB and CSC. We solve the MIT bag boundary condition for the quarks exactly for the basis of our calculation. We then solve the Schwinger-Dyson equation under $q\bar{q}$ and qq interactions. This corresponds to a Hartree-Fock Bogoliubov study with quark confinement and residual interactions. In this approach, we can handle a finite quark system from a small number of quarks ($N_q = 3$) to a large number of quarks ($N_q \gtrsim 100$).

In order to study phase structure of χSB and CSC of the strangelets, we investigate quark masses (gaps) due to χSB and CSC. Also, the total mass of the strangelet is calculated as a function of the quark number N_q to compare our results with observed data.

References

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