Color-$SU(3)$-Ginzburg-Landau effective potential for color superconductors and a complete classification of its vacuum

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Color superconductivity has received much interest in high density quark matter physics. This is a manifestation of the spontaneous color-symmetry breaking by quark-pair condensation due to the attractive interactions. Usually the attractive quark-quark interactions, which make quark-pair condensates stable, are evaluated from the QCD-inspired models, e.g., one-gluon-exchange or instanton-induced-interaction. However the origin of the attractive interactions (especialy in the high density quark matter) are not so clear, thus the applicaion of the Landau theory of the phase transition, the construction of the general effective potential for the broken symmetry and the classification of its vacuum, should be a very impotant approach.

In this talk, Ginzburg-Landau effective potential is studied for the order parameter that transforms in the $\mathbf{3} \times \mathbf{3}$ representation under the color $SU(3)$ group, in which the color space of the order parameter is incorporated. All the $SU(3)$ invariant terms up to the fourth order of the order parameter are classified and the effective potential is constructed in its most general form. The conditions which stabilize the condensed phases are also obtained. As simple applications, the classification of the condensed phase is discussed in some special cases and the Higgs phenomenon associated with symmetry breaking is studied by introducing a coupling to the gauge boson.

Complete phase diagrams are obtained to any possible values for coupling constants of the $SU(3)$ invariant terms in the effective potential. Each phase is classified into $\mathbf{3}^*$, $\mathbf{6}$ and $\mathbf{3}^* + \mathbf{6}$ (Mixed phase) according to the residual symmetry, since the irreducible decomposition of the order parameter is $\mathbf{3} \times \mathbf{3} = \mathbf{3}^* + \mathbf{6}$.

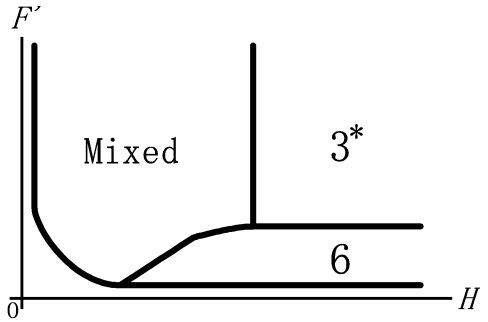

Figure 1: A typical example of the phase diagram. The F', H are two of the coupling constants in the effective potential (other parameters are fixed with some values).

References

[1] E. Nakano, T. Suzuki and H. Yabu, TMU-NT-preprint 2002-2.