Screening Effect at Quark-Hadron Mixed Phase

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It is now commonly accepted that various phase transitions may occur in neutron star interiors. Possibilities of the pion and kaon condensate states, and the quark matter were studied by many authors during last thirty years. Recent progress in observations of neutron stars might reveal such new form of matter.

It has been argued that these are first order phase transitions and two spatially bulk phases are described by the Maxwell construction. Glendenning raised a question on possibility of appearance of mixed phases in such systems composed of charged particles by invoking the proper treatment of the Gibbs conditions [1]. Disregarding effects of inhomogeneity of the particle configurations and the electric field, many authors have demonstrated energetic preference of the mixed phase and existence of a wide region of the mixed phase.

However such bulk calculations have been proved to be too crude for the discussions of structured mixed phase. Instead, careful consideration of the interface of two phases is required. In recent papers we have presented a framework to deal with inhomogeneous density profiles and the electric field selfconsistently [2]. Our framework is rather general and it may be applicable to any first order phase transition. Manifestly keeping the gauge invariance for the electric field during the course, we have also noted how picture of the mixed phase is changed by the gauge choice.

Applying this idea, possibility of structured mixed phase at hadron-quark phase transition in neutron stars is studied, by taking into account charge screening and surface effects. We consider two possibilities, the mixed phase and two separate bulk phases given by the double-tangent (Maxwell) construction.

We demonstrated that the charge screening effect should greatly modify the description of the mixed phase, changing the kinetic stability of droplets, rods or slabs and affecting the possibility of the mixed phase. In absence of the mixed phase we have two bulk phases existing within the double-tangent (Maxwell) construction, without spoiling the Gibbs condition.

Some remarks for the case of kaon condensation are also given.

References

[1]N.K. Glendenning, Phys. Rev. D46 (1992) 1274.

[2]D.N. Voskresenky, M. Yasuhira and T. Tatsumi, Phys. Lett. B, to be published (nucl-th/0109009); Nucl. Phys. A, to be submitted.