Nuclear Theory

Mixed phases during the phase transitions

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Quest for a new form of matter inside compact stars compels us to examine the thermodynamical properties of the phase transitions. We closely consider the first-order phase transitions and the phase equilibrium on the basis of the Gibbs conditions, taking the liquid-gas phase transition in asymmetric nuclear matter as an example. Characteristic features of the mixed phase are figured out by solving the coupled equations for mean-fields and densities of constituent particles self-consistently within the Thomas-Fermi approximation. The mixed phase is inhomogeneous matter composed of two phases in equilibrium; it takes a crystalline structure with a unit of various geometrical shapes, inside of which one phase with a characteristic shape, called "pasta", is embedded in another phase by some volume fraction. This framework enables us to properly take into account the Coulomb interaction and the interface energy, and thereby sometimes we see the mechanical instability of the geometric structures of the mixed phase. Thermal effect on the liquid-gas phase transition is also elucidated.
Similarly hadron-quark deconfinement transition is studied in hyperonic matter, where the neutrino-trapping effect as well as the thermal effect is discussed in relation to the properties of the mixed phase. Specific features of the mixed phase are elucidated and the equation of state is presented.

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