Microphase Formation in Two- and Three-Dimensional Fluids with Competing Interactions

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Competition between a short-range attraction and a longer-range repulsion in the effective pair interaction is not uncommon in colloidal fluids. This occurrence has recently been given much attention because, when the competition is strong, it leads to the formation of large particle aggregates, which may arrange into equilibrium structures (microphases). We have been investigating equilibrium microphase formation due to competing interactions in two- and three-dimensional model fluids. In the two-dimensional case, we have resorted to Monte Carlo simulations to study the phase diagram and the correlations of the bulk system as well as the effect of confinement between parallel hard walls. We find that, depending on the average density, droplet-, stripe-, and bubble-like domains can occur. Strong confinement affects both the stripe orientation and the stability of the stripe phase at low temperature. Microphase formation in three-dimensional fluids has been addressed by density-functional theory; so far we have focused on stripe-like structures, whereby the density is modulated along one direction. The theory predicts that the transition from the uniform to the modulated phase can be either second- or first-order, with the second-order transition line terminating into two tricritical points. When the competition between attraction and repulsion is not so strong as to suppress bulk fluid-fluid phase separation, the tendency towards clustering can still be detected from the enhancement of density fluctuations, which affects the crossover to the critical regime and leads to the persistence of the oscillatory decay of the correlations for states close to criticality.