Static and dynamic properties of two-dimensional systems with competing interactions

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In contrast to atomic materials, soft matter systems show a wide range of particle interactions that can be easily modified, for instance by changing the solvent or its salt concentration and pH value. Using these measures, the particle interactions in soft matter systems can be tuned in such a way that a short range attraction competes with a long ranged repulsion. At low temperatures, systems with this kind of competing interactions are known to self assemble into so-called microphases, i. e. periodic domains of high particle density surrounded by a low particle density fluid, instead of phase separating into one high and one low density liquid phase.

My thesis is dedicated to a model that features such competing interactions. I use the framework of liquid state theories based on the Ornstein-Zernike equation and Monte Carlo simulations to explore the parameter space of this model potential to find those potential parameter combinations that favor microphase formation rather than bulk phase separation. I find that a sufficiently strong long ranged repulsion guarantees the formation of microphases at low enough temperatures. Furthermore, I investigate the dynamic behavior of clusters of particles as well as of the individual particles in the cluster-microphase formed at low densities, using extensive Monte Carlo simulations. I find, that the particle clusters only form ordered structures above a certain particle density, while remaining mobile down to the lowest investigated temperatures, at lower densities. Finally, the effect of a disordered porous matrix on the properties of a fluid of particles with competing interactions is studied. I find that in these so-called quenched-annealed systems the cluster forming fluid particles are either adsorbed into the matrix or avoid the matrix particles, depending on the interaction between fluid and matrix.