# Theory of inhomogeneous condensed matter

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Research activities concerning ***Critical Phenomena***

Upon approaching the critical point of continuous phase transitions, the correlation length diverges and thus renders, to a large extent, microscopic details irrelevant. This leads to universal power laws and scaling functions for static and dynamic properties. Such critical states of matter are highly correlated and particularly sensitive to external perturbations. In this context the research group has recently obtained the following results:

- The confinement of critical fluctuations alters their spectrum and leads to effective forces on the confinement known as critical Casimir forces. These forces have been experimentally determined by monitoring the thicknesses of wetting films near critical end points for $^4$He and classical binary liquid mixtures as well as near the tricritical end point of $^4$He-$^3$He mixtures. By using fieldtheoretic renormalization group theory and novel Monte Carlo simulations, the universal scaling functions for the corresponding critical Casimir forces have been calculated for various universality classes and boundary conditions. Very good quantitative agreement with the aforementioned experimental results have been obtained.
- In a combined theoretical and experimental effort together with Prof. Bechinger's group the critical Casimir force acting on colloidal particles near a wall in a critical solvent has been determined directly. Depending on the boundary conditions at the surfaces the critical Casimir force is attractive or repulsive, the latter opening interesting perspectives for overcoming stiction in nanomachines. There is excellent quantitative agreement between the theoretical predictions and the experimental data.
- The critical adsorption on nonspherical colloidal particles has been calculated.
- The interplay between critical Casimir forces and the omnipresent algebraically decaying dispersion forces has been analyzed.
- Lateral critical Casimir forces between geometrically structured walls have been calculated.
- The interplay between complete wetting, critical adsorption, and capillary condensation has been elucidated.

Ongoing research activities encompass the normal and lateral critical Casimir forces between a sphere and a chemically structured substrate, critical Casimir torques, many-body critical Casimir forces, effect of continuously tuned boundary conditions on critical Casimir forces and the coupling between critical adsorption and ion distributions.