Project 3.3 Interactions mediated by fluctuating medium in and out-of equilibrium

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Background:

Behavior of soft matter systems can be understood from the balance of effective forces emerging beyond the direct microscopic molecule or particle interactions. Especially interesting - because of their universality - are effective forces which arise from spatially correlated fluctuations, i.e., when fluctuations reach across mesoscopic distances in space. These so-called fluctuation-induced forces have been measured in a large variety of systems and setups at the micrometer length scale. Prominent examples of spatially correlated fluctuations are found, among others, in fluid media near a critical point, causing the so-called critical Casimir effect. These examples have been shown to comprise interesting equilibrium and non-equilibrium behaviors, but out-of-equilibrium situations such as active particles open up even wider avenues that have yet to be explored.

Over the years, the importance of Casimir forces in various soft matter systems have been identified. Yet, the exact role of this effect in the large-scale collective behavior in suspension of colloids and in lipid membranes is not fully understood.

Aim:

This project focus on the theory and applications for self-assembly of effective forces emerging between passive and active objects immersed in a binary liquid mixtures close to the critical demixing point. The project is theoretical and computational but will benefit from empirical data and close collaborations with experimental colleagues. The scientific goal of this project is threefold: to build on our expertise in modelling fluctuation-induced forces in equilibrium to firstly, gain insight into temperature controlled assembly of two types of particles into colloidal alloys and, secondly, to elucidate the physical determinants of the formation of lipid and protein domains in membranes. The third goal is to expose the basic physical principles of the interaction of active particles and, furthermore, uncover dynamical consequences of these forces that can range from trapping, scattering and simple or complex orbits. Our well-controlled model systems will provide insight into the fundamentals of non-equilibrium physics.

Requirements:

- Master degree in physics, chemistry or material science,
- good analytical and numerical skills,
- motivation for scientific work and the ability to work in a group,
- very good knowledge of English in speech and writing.