The Critical Casimir Effect and its Application to Nanoparticle Assembly

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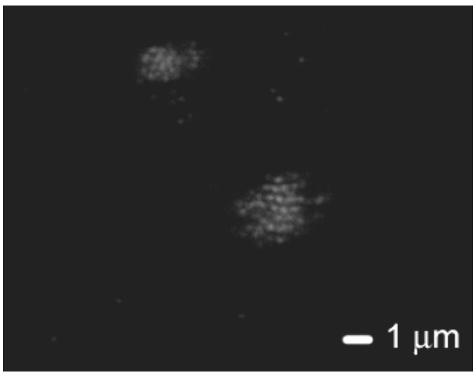
Critical Casimir forces originate from fluctuations of a binary liquid mixture close to its critical point. When these liquid fluctuations are confined between two surfaces that are submerged in the liquid at close distance, this causes interactions between the two surfaces. The interactions can be repulsive (for a non-symmetric boundary condition), or attractive (for symmetric boundaries).

We investigate critical Casimir forces in suspensions of nano and microparticles. Confinement of the solvent fluctuations between the (symmetric) particle surfaces causes attractive interactions that leads to particle aggregation. This effect can be exploited for controlled nanoparticle assembly: Because the critical solvent fluctuations depend on temperature, this offers excellent temperature control over particle interactions.

We have recently shown that by finetuning Critical Casimir interactions, we can induce condensation of the particles into phases that are analogues of atomic liquid and crystal phases [1]. The temperature control of interactions allows us to stear the growth of these phases with external control. We measure the Critical Casimir potential directly from the probability distribution of particles in dilute suspensions, and we follow the formation of liquid and solid phases using optical microscopy as well as light and x-ray scattering [2]. Further experiments are currently in preparation for the International Space Station. While on earth, the particle assembly process is disturbed by gravity, in space, this growth process can be studied without external disturbances. We participate in a running space program to perform these experiments.

Our aim is therefore twofold: We would like to understand and predict Critical Casimir interactions, and their relation to the “regular” Casimir effect. Second, we would like to take advantage of these interactions for controlled nanoparticle assembly.

[1] H. Guo, T. Narayanan, M. Sztucki, P. Schall and G. Wegdam, “Reversible Phase Transition of Colloids in a Binary Liquid Solvent”, *Phys. Rev. Lett.* **100**, 188303 (2008)
[2] D. Bonn, J. Otwinowski, S. Sacanna, H. Guo, G. Wegdam and P. Schall, “Direct Observation of Colloidal Aggregation by Critical Casimir Forces”, *Phys. Rev. Lett.* **103**, 156101 (2009).



Critical Casimir forces in colloidal suspensions
The Critical Casimir force was finetuned to make these particles condense from a dilute ‘gas’ into dense ‘liquid drops’.