CPP 4: Colloids and Nanoparticles II: Effective Interactions

Time: Monday 14:00–15:45   Location: H37

Invited Talk   CPP 4.1   Mon 14:00   H37
Direct measurement of critical Casimir forces — Christopher Hertlein, Laurent Helden, and ●Clemens Bechinger — 2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart

Similar to electromagnetic vacuum fluctuations which can induce long-ranged interactions between uncharged, conducting surfaces, a rather similar effect was predicted almost 30 years ago to occur in confined binary mixtures close to their critical point. This so-called critical Casimir effect has attracted considerable attention because it can strongly modify the interaction potential of colloidal particles immersed in a binary fluid. We present the first direct measurement of such critical Casimir forces between a colloidal particle and a flat surface in a water - 2,6-lutidine mixture. With total internal reflection microscopy (TIRM) which is capable to resolve forces down to 5fN, we obtain distance resolved particle-wall interaction profiles. Upon approaching the critical point we observe long-ranged interactions which are attractive or repulsive depending on the specific boundary conditions of the walls. This behavior is in good agreement with recent theoretical predictions.

CPP 4.2   Mon 14:30   H37
Testing a morphological theorem for the solvation energy of non trivially shaped objects — ●Florian Pesth and Martin Oettel — Institute of Physics, Johannes Gutenberg-University, 55099 Mainz

For a given solvent, the grand potential in a finite volume in general depends in a complex way on the shape of the container, or alternatively, the solvation energy of a large solute depends in a similarly complex way on the shape of the molecule. A morphological theorem states [1], that if some physical restrictions are imposed on the container or the solute, the grand potential depends on only four quantities, namely the volume, the surface area, the integrated mean curvature and the Euler characteristic of the container or the solute. We test this theorem in an approach which combines integral equation methods with density functional theory which allows to calculate the solvation energy of large molecules. This appears to be relevant for applications of this morphological theorem to the configuration dependent solvation energy of macromolecules [2].

[1] P.-M. König, R. Roth, and K. R. Mecke, Phys. Rev. Lett. 93, 160601 (2004)
[2] R. Roth, Y. Harano, and M. Kinoshita, Phys. Rev. Lett. 97, 078101 (2006)

CPP 4.3   Mon 14:45   H37
Theoretical study of a liquid-vapor interface and effective interactions between colloids at interface — ●Vitalie Botan and Martin Oettel — Institut für Physik, WA 331, Johannes-Gutenberg-Universität Mainz, D-55099 Mainz, Germany

We present a microscopic theory combined of integral equations and density functional theory to study the liquid-vapor interfacial properties of simple liquids. The asymptotic behavior of the density profiles, inhomogeneous two-body correlation functions and their implication for the surface tension are analyzed with respect to the mesoscopic capillary wave picture. In contrast to mean-field theories of the interface we observe fairly strong feedback of the pair correlation function to the density profile. The developed methods are applied to the study of interfacial effects in the effective interaction between colloids trapped at the interface.

CPP 4.4   Mon 15:00   H37
Structure of charged colloids in three dimensions and in films: How important is the salt ? — ●Sabine Klapp[1,2], Dan Qu[1], and

Regine von Klitzing[1] — [1]Stranski-Laboratorium für Physikalische und Theoretische Chemie, Technische Universität Berlin — [2]Institut für Theoretische Physik, Technische Universität Berlin

Using computer simulations and (hypernetted chain) integral equations we investigate the structure of charged colloidal suspensions in bulk and in spatial confinement (film geometry), focusing on the identification of characteristic length scales. The calculations are based on an effective description of the multicomponent colloidal suspension via a screened Coulomb (DLVO) potential between the macroions. The range of the interaction is controlled by the inverse Debye length κ determined by the concentrations of counterions and the ionic strength of additional salt (if present). Concerning bulk properties, we find that the commonly accepted power law $\xi \propto \phi^{-1/3}$ for the average particle distance $\xi = 2\pi/q_{max}$ in three spatial dimensions describes the results only for low ionic strength, that is for relatively long–ranged potentials characterized by small values of κ. On the other hand, systems with larger ionic strengths do not obey such power–law behavior and rather resemble an uncharged hard–sphere fluid, where the relevant length scale is the particle diameter. Similar observations hold in a film geometry. For both geometries, our results for suspensions with low salt concentration are in excellent quantitative agreement with experimental results for charged Silica particles.
S. H. L. Klapp, D. Qu, and R. v. Klitzing, J. Phys. Chem. B, in press.

CPP 4.5   Mon 15:15   H37
Effect of confinement on the structuring within colloidal suspensions: A comparison between theory and experiment — ●Regine v. Klitzing, Dan Qu, Yan Zeng, and Sabine Klapp — TU Berlin, Stranski-Laboratorium, D-10623 Berlin

Small angle neutron scattering experiments at suspensions containing Silica particles show a structure peak which indicates interactions between the particles. The position of the structure peak scales with the concentration c with an exponent 1/3. In order to study the effect of geometrical confinement the solutions are confined between a microsphere and a flat interface in a Colloidal–probe AFM. Oscillatory forces are measured due to layer – by – layer expulsion of the particles. The period has the same value as the particle distance in the corresponding bulk solution calculated from the position of the structure peak. The addition of salt reduces the amplitude, i.e. the ordering of the particles, and the scaling exponent of the particle distance in dependence of the concentration. The latter effect is observed for the first time. All results can be perfectly fitted by a theoretical model assuming a DLVO potential.

CPP 4.6   Mon 15:30   H37
A Pre-Wetting Transition on Colloidal Particles — Andreas Erbe[1], Klaus Tauer[2], and ●Reinhard Sigel[2] — [1]Institute of Physics, Academia Sinica, Taiwan — [2]MPI of Colloids and Interfaces, D-14476 Golm

The salt concentration around charged colloidal particles is traditionally described by the Poisson-Boltzmann equation. Not predicted by this equation is a sudden transition to a layer of high salt concentration around the colloids when the average salt concentration is enhanced. This transition has been found experimentally by ellipsometric light scattering [1]. The observation is interpreted as a first order pre-wetting transition. The interactions stabilizing the layer of enhanced concentration as well as the extent and the softness of the layer are discussed. The pre-wetting by a highly concentrated salt solution can also explain an experimental finding for charged spherical brushes composed of polyelectrolytes around colloidal particles. Here, a concentration profile similar to uncharged spherical brushes is detected, instead of the streched chain behavior predicted by theory.

[1] A. Erbe, K. Tauer, R. Sigel, Langmuir, in press.