

PHASE TRANSITIONS AND VITRIFICATION IN TWO-DIMENSIONAL COLLOIDAL SYSTEMS

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Keywords: colloids, 2D melting, phase transitions, glass transition

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It is well known that dimensionality affects phase transitions. Whereas nucleation of supercooled fluids in three dimension is a first order phase transition including phase equilibrium, the melting process in a two-dimensional system in equilibrium has been a matter of debate for long. While Kosterlitz and Thouless proposed a continuous transition induced by topological defects like dislocations at the melting temperature T_m , Chui later argued for a first order transition similar to the case in three dimensional systems. Here, the symmetry is restored in the high temperature phase by the spontaneous generation of grain boundaries. The presence of a hexatic phase, an intermediate phase between the isotropic liquid and the crystalline state, was predicted by Nelson and Halperin, as extension of the theory by Kosterlitz and Thouless. The hexatic phase is an anisotropic fluid and a second type of topological defects, namely disclinations, are needed to restore isotropy at a higher temperature T_i and Young independently calculated the critical exponents at the melting temperature. As colloidal systems are excellent model systems to observe phase transitions with single particle resolution, we were able to investigate the microscopic mechanism of the so-called KTHNY-theory based on defect unbinding. This was done by analyzing the time resolved trajectories of micrometer sized particles visualized with video-microscopy confined at flat water/air interface of a hanging droplet.

Using positional data from a bi-disperse colloidal mixture in two dimensions we can also investigate vitrification since our binary mixture does not crystallize. We analysed the mean square displacement (MSD) showing a plateau on intermediate timescales and an α -relaxation process on logarithmic time scales. Dynamic heterogeneities appear on the timescale of the α -relaxation and the self part of the Van Hove function shows an exponential tail below the glass transition temperature T_g . Nevertheless small crystallites with distinct stoichiometries appear on a local scale in the supercooled state. Knowing the particle pair potential we were able to map dynamical heterogeneities to a structural quantity. The latter was determined by the discontinuous behavior of the shear modulus, jumping to zero at T_g .

Acknowledgments: This work was supported by the German Research Foundation (DFG).