Elastic properties, structures and phase transitions in model colloids

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The nature of the melting transition for a system of hard disks with translational degrees of freedom in two spatial dimensions has been analyzed by a combination of computer simulation methods and a novel finite size scaling technique. The behavior of the system is consistent with the predictions of the KTHNY theory.

The structural and elastic properties of binary colloidal mixtures in two and three spatial dimensions are discussed as well as of colloidal systems with quenched point impurities.

Hard and soft disks in external periodic (light-) fields show rich phase diagrams including freezing and melting transitions when the density of the system is varied. Monte Carlo simulations for detailed finite size scaling analyses of various thermodynamic quantities like the order parameter, its cumulants etc., have been used in order to map the phase diagram of the system for various values of the density and the amplitude of the external potential. For hard disks we find clear indication of a reentrant liquid phase over a significant region of the parameter space. The simulations therefore show that the system of hard disks behaves in a fashion similar to charge stabilized colloids which are known to undergo an initial freezing, followed by a re- melting transition as the amplitude of the imposed, modulating field produced by crossed laser beams is steadily increased. Detailed analysis of the simulation data shows several features consistent with a recent dislocation unbinding theory of laser induced melting. The differences and similarities of systems with soft potentials (DLVO, $1/r^{12}$, $1/r^{6}$) and the relation to experimental data is analyzed. Besides these classical studies we discuss the validity of our results on atomic length scales. The modifications of the phase diagram for quantum hard disks with finite particle masses, obtained by path integral Monte Carlo simulations indicate a new quantum melting scenario, absent in the classical case.