



Freezing Transitions in A Two-Dimensional System of Model Ultrasoft Colloid and Pair Correlation Functions

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Abstract

The study of freezing transitions in two-dimensional colloidal systems provides important insights into phase behaviour, structural ordering, and interparticle interactions at reduced dimensionality. This work investigates the freezing behaviour of a model two-dimensional system of ultrasoft colloids, with particular emphasis on the structural information obtained from pair correlation functions. Unlike conventional hard-core particles, ultrasoft colloids can partially overlap and exhibit bounded or smoothly varying effective interactions, resulting in distinctive phase transitions and structural characteristics. The analysis examines how thermodynamic and structural parameters, including particle density, temperature, and interaction strength, influence the transformation from a disordered fluid phase toward an ordered or partially ordered solid state. Pair correlation functions are employed to characterize local and intermediate-range structural organization by describing the probability of finding particles at specific separations. Changes in the position, height, and width of correlation peaks provide valuable evidence for the development of translational and positional order near the freezing regime. The study also considers the role of competing interaction effects in determining the stability and nature of the emerging phases. Understanding these structural signatures is essential for identifying freezing points and distinguishing different states of matter in two-dimensional soft-matter systems. The findings contribute to a broader understanding of phase transitions in ultrasoft colloidal materials and may provide useful theoretical insights for the design and control of two-dimensional colloidal systems.

Keywords: Two-Dimensional Systems, Ultrasoft Colloids, Freezing Transition, Pair Correlation Function, Phase Transition, Colloidal Systems, Structural Ordering, Soft Matter, Particle Interactions, Fluid–Solid Transition.