Title of the Thesis

Studies of ordering in equilibrium and non-equilibrium systems

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Abstract

In this thesis we explore two problems involving subtle forms of ordering in condensed matter systems. The first problem models the radial positioning of chromosomes according to gene density in the nucleus of a living cell, while the second concerns the ordering of particles in a colloidal drop on evaporation of the solvent. In the first chapter, we provide a brief introduction to the terminology used in Part − I of this thesis. A short introduction to active matter and its modeling using physical theory are described in Chapter 2. In Chapter 3, we describe simulations of chromosomes assuming chromatin to be active matter. We describe fluctuations arising from activity in terms of an effective non-equilibrium temperature associated to local transcription levels. We show in Chapter 4 that accounting for activity provides a natural solution to two outstanding problems in nuclear architecture: the emergence of a territorial organization of chromosomes and the origin of non-random positional distributions of chromosomes based on gene density. The predictions of the model are shown to agree reasonably with the experiments. Our model is also able to produce size dependent radial positioning of chromosomes, yielding good agreement with experimental data. In Chapter 5, we study a simplified version of our model for chromosome positioning, examining the systematics of spatial segregation in a two-component mixture of active and passive mono-disperse polymers in a confined spherical geometry. In Chapter 6, we provide a short introduction to the self-assembly of colloidal particles due to evaporation of a colloidal suspension on a substrate as seen in recent experiments which we model in Part − II of this thesis. In Chapter 7, we study the structure and dynamics of a drop of colloidal suspension during evaporation of the solvent using a phase field crystal model. Evaporation of the drop produces an ordered or disordered arrangement of the colloidal residue depending only on the initial average density of solute and the drying rate. In the last chapter of this thesis, we generalize our phase field crystal model to a symmetric binary mixture of two species of mutually repulsive colloidal particles. The dynamical phase boundary in the density-drying time plane is very similar to the analogous phase boundary in the single component system.