

Fluctuation Driven Systems: from Glassy Dynamics of Associating Polymers to Deformations of Liquid Crystalline Polymers

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ABSTRACT

Fluctuation driven heterogeneous cooperative dynamics and self-organization are signatures of a diverse class of physical systems from polymer (and colloidal) glasses to biopolymers. In this presentation, I will talk about two of such systems where, either fluctuation-controlled dynamics or, effect of fluctuations around mean-field state of the system are crucial. *Firstly*, formulation of a microscopic liquid state theory of how attractive functionalities between sticky groups regularly co-polymerized in a chain backbone affect local structure and segmental dynamics of unentangled polymer liquids will be discussed. Based on the bare attractive interaction and single-chain structure as input, integral equation theory is combined with activated dynamics approaches that capture caging and physical bond formation to study emergent high frequency elasticity and local relaxation processes. The dynamic free energies and corresponding sticker and non-sticker barrier hopping timescales that define the coupled bond breakage and cage escape processes are predicted within a 2-step dynamical scenario that applies in the strong attraction regime. The first step involves non-sticker hopping (alpha relaxation) that is perturbed due to physical bonds between sticky segments that act as pinning constraints. This theoretical development will be supplemented by a discussion on the comparison of the theory predictions for alpha relaxation time and the glass transition temperature of associating polymers with experimental results. *Secondly*, building on the exact single-chain statistics of semiflexible polymers and mean-field solutions for both isotropic and nematic states, I will talk about extending a theory for the free energy functional of semiflexible polymer solution with alignment interaction up to quadratic order to specifically understand the three Frank elastic (FE) constants of long wavelength splay, bend, and twist modes of deformation. Enhanced alignment of polymers in their nematic state are responsible for crucial mechanical and material properties of fibers found in both biological systems and chemical physics. These deformations characterize the normal modes of the deviation of local nematic director field of liquid crystalline behavior. The theoretical picture suggests the three FE constants can be exactly mapped to correlation functions involving real spherical harmonics. Numerical simulations supplementing theoretical discussion suggests excellent agreement and presented theory serves as a basis for understanding protein-brush induced membrane deformations important for membrane tethering and fusion.