Phase transitions in polymers and liquids in electric field gradients

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Electric fields can give rise to order-order, order-disorder and orientational phase transitions in liquids and polymers. In addition to orienting ordered phase of block copolymers (e.g. lamellae), electric fields can change the critical point of the melt as well as the transition lines between the phases. We show that nonuniform fields can lead to curving of lamellae, and study the competition between elastic and electrostatic forces. When applied to liquid mixtures, nonuniform fields lead to a demixing phase transition. We describe the statics and dynamics of this "electro prewetting" transition, as well as several interfacial instabilities which appear. When applied on simple fluids field gradients can lead to a nucleation of a gas bubble from a homogeneous liquid or to nucleation of a liquid drop from a homogeneous gas. We calculate the pressure tensor and the surface tension in these systems. The demixing phase transition has important implications for the stability of colloidal suspensions. Indeed we show that the forces between colloids in mixtures can be strongly attractive even if the ions are monovalent, there are no surface patches and within a simple mean-field Poisson-Boltzmann framework. We explore several interesting consequences of the phenomenon such as (i) separation of liquids in microfluidic channels, (ii) control of the spatial and temporal kinetics of chemical reactions, and (iii) control of biological polymerization (actin).

References

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