Structural and phase behaviour of mixtures of nanoparticles and liquid crystals

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We have studied theoretically and experimentally the coupling interaction between liquid crystal (LC) molecules and nanoparticles (NPs) in LC+NPs mixtures. Such systems exhibit complex phase and structural behaviour revealing a balance among elastic interactions, surface interactions and disorder. In order to study phase separation tendencies of a mixture of LC and strongly anisotropic NPs we combine Landau-de Gennes and Doi approach (1). We analyse phase behaviour for different coupling strengths between LC and NPs. Our investigation shows that geometric properties of NPs play significant role, in particular the diameter of nanoparticles. Using the same model we also determine conditions, where LC phase behaviour is enslaved by NPs (2). Furthermore, we focus on domain-type properties of LCs for cases where NPs impose a random-field type of disorder. Using different lattice type simulations we show that Imry-Ma scaling prediction on average domain size is obeyed only for appropriate system histories. Experimentally we focus on magnetoelectric properties of anisotropic magnetic NPs and a ferroelectric LC. We demonstrate such systems can be used as soft magnetoelectrics. Namely, ferroelectric LCs gives rise to spontaneous electric polarisation $\vec{P}$ and magnetic particles to effective magnetization $\vec{M}$. A memory element with such properties would permit an electric write operation combined with a magnetic read, eliminating the need for the destructive read (and reset) in present-day ferromagnetic RAMs, thus making possible fatigue-free memories. We further show that such systems could be used as a sensitive detectors using the stochastic resonance phenomenon (3).

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