INTERACTION AND FORMATION OF STRUCTURES IN LIQUID CRYSTAL COLLOIDS AND EMULSIONS

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S u m m a r y

This article surveys new results on the interaction and the formation of structures in liquid crystal (LC) colloids and emulsions. We present the analytical results concerning the possible structures for suspensions of macroparticles in liquid crystals. We have shown that the formation of different structures can occur in liquid crystals for realistic values of the temperature and the concentration of macroparticles. If particles with dimensions being much larger than those of molecules of LC are immersed in LC, we can observe the peculiar properties in a new medium. Those can be solid insoluble particles or admixtures of another liquid introduced to LC. In the first and second cases, those are, respectively, LC colloids and emulsions. Because of a large enough surface, such particles prescribe boundary conditions for the orientation of LC molecules depending on the adhesion to that surface, which leads to a local deformation of the elastic field of the director. Two types of adhesion to the macrodoped surface are distinguished: the strong one and the weak anchoring. In the former case, the surface itself prescribes the director orientation and acts as a source of the director field change. In the latter case, each inclusion acts as a disturbance of the director orientation, because the boundary conditions at the surface do not correspond to the real distribution of the director. First of all, we describe the influence of a separate macroinclusion on a deformation of the elastic field of the director and the scalar order parameter depending on a geometric configuration and dimensions, as well as the boundary conditions on the surface of a separate macroinclusion. It is shown, for instance, that the director distribution around a spherical inclusion under the normal boundary conditions on its surface has a topological defect existing as a hyperbolic hedgehog or a dislocation Saturn's ring. Under tangent boundary conditions on the inclusion surface, the distribution of the director takes a spindle-like shape. If the area of a disturbance is large enough due to the overlapping of the director field deformation areas for two and more macroinclusions, there appears the effective interaction between them.

We have described the methods for determining the interaction energy through the elastic field of a director in the case of the strong or weak anchoring of LC molecules to the surface of a separate inclusion. The effectiveness of such an interaction will be determined, first of all, by the geometric parameters of an inclusion, the adhesion force of LC molecules to the surface of such an inclusion, and the elastic properties of the medium. In the general case, the value and character of the interaction are determined by the value and character of a violation of the director distribution symmetry. We have shown how a violation of the director distribution symmetry at short-range distances defines the interaction at long-range distances. Within the self-consistency approach, we have determined the interaction between macroinclusions in nematic, smectic, and cholesteric LC. We have determined the interaction energy for macroinclusions in the isotropic phase of LC, and the effect of a change in the order parameter on the character and value of such an interaction at short-range distances.

For the first time, the possible structures in the system of macroinclusions in LC are predicted, the conditions for the realization of a hexagonal structure are theoretically obtained, and the physical parameters of such a structure depending on the value and character of the interaction are described. For the system of glycerin drops with tangent boundary conditions on specific drops, the hexagonal structure is experimentally observed. In addition, the structure transformation of such a hexagonal structure to the chain one under the action of an external magnetic field is observed. This makes it possible to study the phase transitions induced by the interaction through the elastic field of the director in such systems and to consider the system as some kind of a display.

We have considered the collective behavior of the system of macroparticles in LC induced by the interaction through the director field. The collective effect of many particles can lead to the formation and mutual transformation of structures, which is visually observed in such a system. Thus, depending on the character and value of the elastic interaction energy in the system of macroinclusions in LC, thermodynamically stable structures with different geometries can appear. We have studied the conditions for the appearance and mutual transformation of the possible periodic structures. We have explained the appearance of both a hexagonal structure in the system of glycerin drops with tangent boundary conditions and chain structures in the system of water drops with normal boundary conditions. We have described the possible structures that can be induced in view of the character of the obtained interaction and have studied the possibility for external fields to influence such structures.