MEETINGS AND CONFERENCES

Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the Academy of Sciences of the USSR (28–29 January 1987)

A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on January 28 and 29, 1987 at the S. I. Vavilov Institute of Physics Problems of the USSR Academy of Sciences. The following reports were presented at the session:

January 28
1. *B. I. Ostrovskiĭ.* Structure of liquid crystals.
2. *L. M. Blinov.* Electro-optics of liquid crystals.

3. *E. I. Kats and V. V. Lebedev.* Dynamics of freely suspended smectic films.

January 29
4. *S. A. Pikin and M. A. Osipov.* Ferroelectricity in liquid crystals.
5. *Yu. M. L'vov and L. A. Feĭgin.* Production and structure of Langmuir films.
6. *L. M. Blinov.* Physical properties and applications of Langmuir films.

Brief summaries of the six reports are given below.

B. I. Ostrovskiĭ. *Structure of liquid crystals.* Investigations of liquid crystals are at present an intensively developing branch of the physics of the condensed state. A study of the properties of liquid crystals (LC) and the further development of the theory of the liquid crystalline state are based first of all on the results of structural investigations, in particular on x-ray structural analysis.

The liquid crystalline state is characteristic for organic molecules that have a strongly anisotropic shape—rods or discs. These compounds on melting do not go over from the crystalline state to the liquid state at once, but form one or several intermediate phases which are characterized by a different degree of orientational (nematics) and translational (smectics) order. In an x-ray experiment actually a measurement is made of the Fourier transform of the correlation density function, the reconstruction of which from the data on scattering enables one to draw conclusions both concerning packing of the LC molecules, and also about the special features of the long-range orientational and translational order in them. The various liquid crystalline phases produce differing patterns of the scattering of x-rays and this enables one to identify them, to establish the symmetry group and the kind of packing of the molecules. From x-ray data one can calculate statistical functions characterizing the different violations of the initial crystalline lattice, and determine the tilting of the molecules and the distribution of the electron densities in smectic layers.

For the investigation of short-range order in the arrangement of molecules of nematic LC one uses the construction of different functions of interatomic (intermolecular) distances. The knowledge of the most probable distances between the molecules combined with the known stereochemical models of them enables one to calculate possible variants of the arrangements of the molecules of the LC. A principal complication connected with deriving structural information from the x-ray spectra of nematic LC is the fact that the structural amplitude of the molecules depends on their orientation with respect to the propagation vector of the incident radiation, while the correlation density function is determined not only by the position of the centers of mass of the molecules but also by their relative orientation: $G = G(\mathbf{r},\Omega)$.

The formation of A and C smectics is associated with the generation of one-dimensional translational order in a three-dimensional liquid. The characteristic feature of such systems is the absence of a true long-range order as a result of the instability with respect to the long-wavelength fluctuations of the phase of the order parameter. As a result the correlation function $G(\mathbf{r})$ is no longer a constant as $r \to \infty$, but falls off algebraically as $r - \eta$, where η is a small index. In such a case the sharp Bragg peaks which are characteristic for three-dimensional crystals are replaced by power-type singularities of the form $(q - q_0)^{-2+\eta}$. X-ray investigations show that the A smectics produce narrow scattering lines in the neighborhood of the wave vector of the structure $q_0 = 2\pi/d$ (d is the period of the smectic layers), characteristic of perfect crystals. The size of the region of homogeneity of the A smectic in which no phase disruption of the order parameter occurs amounts at the point of transition into a nematic to a value of the order of 5–6 μm (10^3–$10^4 d$).

Liquid crystals which have a strong polar group at one of the ends of the molecule form smectic phases with a period of the layers incommensurate with the length of an individual molecule. In some cases smectic A and C phases arise where periodic structures are present simultaneously with wave vectors corresponding to the packing of different structural "units" of the LC. Such incommensurate smectic LC remind one by their properties of incommensurate phases in ferroelectrics and solid solutions of substitution type.

Of great interest in respect of their structure are the so-called "exotic" smectics—three-dimensional bodies that have in comparison with the A and C smectics a different degree of positional order in their layers or order in the orientation of the bonds (crystallographic axes). X-ray investigations carried out with a high resolution show that phases which have earlier been classified as B smectics in many substances are in fact not liquid crystals, but lamellar systems with a true long-range order in three dimensions. However, there are also examples when the smectic B-phase represents a pile of hexatic layers with long-range order in bond orientation and a short-range translational order. There are reasons to assume that the special features of a number of new LC phases (F, I and others) are associated with some form or another of dipole ordering of molecules. In such LC systems incommensurate structures arise, and smectics with a modulation of layers are found.

Both orientational and translational order is possible also in systems consisting of disc-shaped molecules. In smectic phases such molecules instead of layers form columns containing piles of disc-shaped molecules. For these phases a two-dimensional hexagonal arrangement of the centers of mass of the molecules is characteristic, with the translational order being absent in the direction perpendicular to the planes that are formed. Such a type of LC corresponds to a two-dimensional density wave in a three-dimensional liquid.

Of great importance for determining the nature of the transition from two dimensions to three dimensions is the study of freely suspended liquid crystal films in which it is possible to produce a controlled increase in the number of molecular layers. In such systems with a small number of layers n ($n \lesssim 20$) it is possible to observe smectics which are piles of hexatic layers. These properties do not manifest themselves within the bulk of a liquid crystal. One should also note liquid crystal structures which have no center of inversion. Such systems formed by chiral molecules include cholesteric liquid crystals, chiral C smectics and the blue phase of cholesterics.

In conclusion we list problems which appear to be at present the most important ones for the study of the structure of liquid crystals.

1. The reconstruction of the form of the correlation function $G(\mathbf{r};\Omega)$ which depends both on the position of the centers of mass of the molecules, and also on their orientation in nematic liquid crystals.

2. The study of the special features of long-range order in layered systems with one-dimensional and two-dimensional translational order. To this belong A and C smectics, the lyotropic phases L_α and L_β, model membranes, and discotics.

3. Investigation of the "exotic" smectics of the type B, F, I, etc.

4. The study of systems with a reduced dimensionality of the space with the aim of determining the conditions for and the nature of the transition from two dimensions to three dimensions. This refers to such systems as freely suspended LC films, layers of amphiphilic molecules on the surface of a solvent, surface layers of LC, thin Langmuir-Blodgett films.

5. Investigation of incommensurate layered structures and smectics with modulation of layers in liquid crystals consisting of polar molecules.

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