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The scientific session of the General Physics and Astronomy Division of the USSR Academy of Sciences was held on October 27 and 28, 1982 at the P. N. Lebedev Institute of Physics. The following reports were presented at the session:

27 October

1. E. I. Kats, Fluctuations of the order parameter in liquid crystals.
2. S. V. Manakov and V. E. Zakharov, Propagation of ultrashort optical pulses in laser amplifiers.
3. E. I. Shtyrkov, Generation of spatially periodic structures of superimposed atomic states.

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4. V. N. Ageev, Absorption-Desorption processes on solid surfaces.
5. B. A. Tverskoĭ, Magnetospheric-ionospheric interaction and polar auroras.

Summaries of four of the reports are published below.

E. I. Kats. *Fluctuations of the order parameter in liquid crystals.* Intensive investigations of liquid crystals have continued in recent years. Interesting new properties of known types of liquid crystals[1,2] and new liquid crystalline structures[4] have been discovered[3] and studied. We shall examine two illustrative examples in what follows.

1. *Smectic A.* The elastic energy of smectic **A** is described by a well-known expression that conforms to the Landau-Peierls theorem for a three-dimensional body with a one-dimensional density modulation:

$$F=\frac{1}{2}\int d^3x\,[B(\nabla_{\parallel}u)^2+K_1(\nabla_{\perp}^2u)^2], \tag{1}$$

where B and K_1 are elastic moduli and u is the displacement of the smectic layers.

The mean-square fluctuation of the displacements diverges logarithmically, and this makes the smectic A look like a two-dimensional system. There is, however, a significant difference between smectic A and two-dimensional systems. The point is that expression (1) for the free energy corresponds to the so-called Lifshitz point, i.e., a critical point at which the coefficients in front of several (m) components of the square of the gradient (in this case $m=2$) vanish. At the Lifshitz point, the interaction of fluctuations is considerable and the Gaussian behavior, corresponding to (1), is unstable. However, in this case symmetry forbids interaction of fluctuations that do not vanish in the long wavelength limit. For this reason, the Gaussian indices of the correlation function change. The most dangerous interaction

$$H_{\rm int}=\frac{\gamma_0}{4!}\int(\nabla_{\perp}u)^4\,d^3x \tag{2}$$

leads to logarithmic corrections to the correlation functions. For this reason, from this point of view, smectic A crystals look like a four-dimensional system. We note that in two-dimensional systems (which are not a "Lifshitz point"), there are no dangerous anharmonic interactions. The four-dimensional analogy indicated above is easiest to see directly in terms of the correlation function of the fluctuations of the director, related to fluctuations of displacements $\delta\mathbf{n}_{\perp}=\nabla_{\perp}u$:

$$D_{\perp}=\langle\delta\mathbf{n}_{\perp}\cdot\delta\mathbf{n}_{\perp}\rangle.$$

In the smectic phase

$$D_{\perp}\sim\frac{T}{K_1q_{\perp}^2+B(q_{\perp}^2/q_{\parallel}^2)}.$$

If we introduce the polar angle $p=\cos\theta$, then the dangerous interaction is important for $p\ll 1$ and in this region

$$D_{\perp}\sim\frac{T}{K_1q^2+Bp^2},$$

i.e., the correlation function corresponds to the four-dimensional model.

Interaction of fluctuations leads in smectic A crystals to logarithmic corrections to the elasticity moduli ($\delta B\sim(\ln q_{\parallel}a)^{-4/5}$, $\delta K_1\sim[\ln(q_{\perp}a)]^{2/5}$ (a is the molecular size)), light-scattering cross section, susceptibility, etc. Such nonanalytic corrections limit the applicability of the hydrodynamic expansion of the free energy with respect to small gradients. On the other hand, experimentally it is easier to observe these logarithmic corrections from the magnetic-field dependence of the light-scattering cross section in different polarizations. The corresponding equations are presented in Ref. 2.

2. *Complete crystallization of diskotic liquid crystals.* Diskotic liquid crystals, recently discovered by Chandrasekhar *et al.*,[3] consist of a system of columns,

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forming a two-dimensional lattice (i.e., this is a two-dimensional solid and simultaneously a one-dimensional liquid). With complete crystallization of a diskotic liquid crystal, i.e., a transition to a true three-dimensional crystal, a modulation of the density is created along the liquid columns:

$$\delta\rho = \frac{1}{\sqrt{2}}\left(\psi e^{i\mathbf{q}_0\mathbf{x}} + \psi^* e^{-i\mathbf{q}_0\mathbf{r}}\right), \tag{3}$$

where $\mathbf{q}_0$ is the wave vector of the modulation, while ψ plays the role of the order parameter for the transition.

The expansion of the Landau free energy in powers of ψ, taking into account local invariance of the system relative to one-dimensional rotations of the system of liquid columns and director, is:

$$F = \frac{1}{2}\int d^3x\left[a|\psi|^2 + \frac{1}{2}b|\psi|^4 + c_\parallel|\nabla_\parallel\psi|^2 + c_\perp|(\nabla_\perp - iq_0\delta\mathbf{n})\psi|^2\right] + F_{el}, \tag{4}$$

where F_{el} is the elastic energy of the diskotic.

It is interesting to note that the interaction of the order parameter with fluctuations of the director $\delta\mathbf{n}$ does not change the nature of the phase transition. In this respect, the situation is not at all similar to the problem of the superconductor-of-the-first-kind—normal metal or nematic–smectic A phase transition, where the elimination of the gauge field (A or $\delta\mathbf{n}$) leads to ψ^3 terms in the expansion of the free energy and, therefore, to a first-order phase transition. In this case, an analogous procedure leads to a ψ^5 term and, for this reason, does not change the nature of the transition. Thus the diskotic–crystal transition is a rare case when complete crystallization is a second-order phase transition. In real diskotic liquid crystals, this transition is a first-order phase transition, although weaker than the melting transition in ordinary molecular crystals. The first-order nature of the transition could be related to the interaction of the order parameter ψ with other noncritical degrees of freedom.

[1]G. Grinstein and R. A. Pelcovits, Phys. Rev. Lett. **47**, 856 (1981).

[2]E. I. Kats, Zh. Eksp. Teor. Fiz. **83**, 1376 (1982) [Sov. Phys. JETP **56**, 791 (1982)].

[3]S. Chandrasekhar, *et al*., Pramana **9**, 471 (1977).

[4]E. I. Kats, Zh. Eksp. Teor. Fiz. **75**, 1819 (1978) [Sov. Phys. JETP **48**, 916 (1978)]; E. I. Kats and M. I. Monastyrskiĭ, Pis'ma Zh. Eksp. Teor. Fiz. **34**, 543 (1981) [JETP Lett. **34**, 519 (1981)]; V. G. Kamenskiĭ and E. I. Kats, Zh. Eksp. Teor. Fiz. **82**, 1507 (1982) [Sov. Phys. JETP **55**, 872 (1982)].