ly when the laser-radiation intensity is decreased by a comparatively small amount, in agreement with the experimental data of Ref. 5.

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[1)]Estimates show that the energy contribution made by chemical reactions to the energy balance is negligibly small.

[2)]We note that, generally speaking, the relationship between I and E can vary in wide limits, since the polymer chain can have side branches possessing either a small ionization potential (but with no tendency to carbon-black formation) or the opposite properties.

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Possibility of a second-order transition under liquid-crystal ordering

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A model with a tensor order parameter is considered; it describes, in particular, transitions from an isotropic liquid to a nematic liquid crystal. It is shown that despite the presence of cubic invariants in the Hamiltonian, the system may undergo a second-order phase transition.

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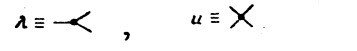
A well-known result of Landau's theory of phase transitions asserts that in the presence of cubic invariants in the Hamiltonian of the system, second-order phase transitions are possible only at isolated points of the phase diagram (corresponding to the vanishing of the cubic terms). In the present paper we shall show that allowance for fluctuations leads to the result that even when threefold invariants are present in the Hamiltonian, second-order phase transition are nevertheless possible.

We consider a system in which a phase transition is described by a tensor order parameter Q_{ij}. We suppose that Q_{ij} is a symmetric tensor with zero trace. It is this situation that occurs, for example, in transitions from an isotropic liquid to a nematic liquid crystal. The Hamiltonian in this case has the form[1]

$$H=\tau Q^2+\lambda Q^3+uQ^4+k^2Q^2. \tag{1}$$

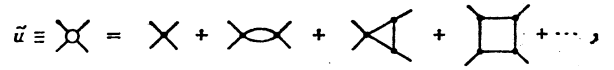
Here Q^2, Q^3, and $Q^4=\frac{1}{2}(Q^2)^2$ are invariants of the second, third, and fourth orders, and k^2Q^2 is a symbolic description of a gradient term.

Near a phase-transition point, determined by the condition $\tau=0$, the singularities of all thermodynamic quantities are expressed in terms of Green's function and the complete renormalized threefold and fourfold vertices $\tilde{\lambda}$ and $\tilde{u}$.[2] The expansion of the complete vertices $\tilde{\lambda}$ and $\tilde{u}$ as series in the bare constants



(2)

has the form



(3)

The solid lines in these expressions denote the renormalized Green's function $G(k)=(k^2+r_c^{-2})^{-1}$ (r_c is the correlation radius). Here and below, we shall set equal to zero the critical index η, which describes the deviation of the correlation function from the Ornstein-Zernke form.

To calculate the threefold and fourfold vertices, we shall use a method proposed by S. L. Ginzberg.[3] This

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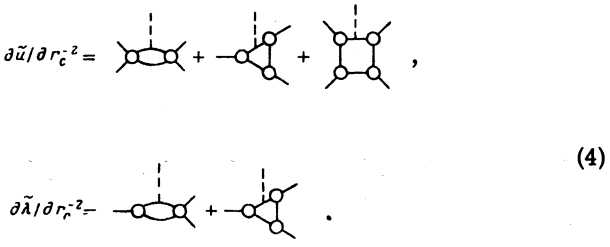
method makes it possible to find all the vertex parts directly in three-dimensional space. As in Ref. 3, we shall take into account only parquet diagrams. Unfortunately one cannot know what results would follow from allowance for the nonparquet graphs that appear in high orders of the perturbation theory with respect to $\tilde{\lambda}$ and $\tilde{u}$.[4] This problem is quite analogous to the problem of allowing for higher orders with respect to $\epsilon = 4 - d$ (d is the dimensionality of the space) in the ϵ-expansion method of Wilson.[2]

On differentiating the expression (3) with respect to r_c^{-2} and carrying out a partial summation, we obtain equations for the complete fourfold and threefold vertices:



(4)

A dashed line in (4) corresponds to differentiation of Green's function with respect to r_c^{-2}.

On substituting in (4) $\tilde{u}$ and $\tilde{\lambda}$ in the form

$$\tilde{u} = g r_c^{d-4}, \quad \tilde{\lambda}^2 = p r_c^{d-6},$$

we obtain the following expressions for the functions $g(r_c^{-2})$ and $p(r_c^{-2})$:

$$\partial g/\partial \ln r_c^{-2} = \psi_1(g, p), \quad \partial p/\partial \ln r_c^{-2} = \psi_2(g, p), \tag{5}$$

where

$$\psi_1 = \frac{d-4}{2} g + a\left[104g^2 - 33(6-d)gp + \frac{75}{64}(6-d)(8-d)p^2\right],$$
$$\psi_2 = \frac{d-6}{2} p + a\left[96gp + \frac{9}{2}(6-d)p^2\right]. \tag{6}$$

Here

$$a = \Gamma(3-d/2)/2^{d+1}\pi^{d/2}.$$

The coefficients in (6) are determined in the usual manner with allowance for the tensorial structure of the order parameter Q_{ij}.

The system (5) is similar to the equations of the renormalization group. The fixed points of the Hamiltonian (1) are determined from the conditions

$$\psi_1(g, p) = 0, \quad \psi_2(g, p) = 0. \tag{7}$$

In particular, for $d = 3$ there exist four limiting points (see Fig. 1), two of which (the first and the second)

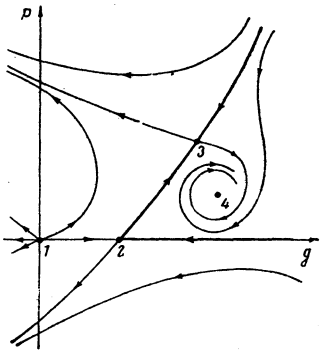


FIG. 1.

were obtained earlier within the framework of the ϵ expansion.[1] The third and fourth points do not approach zero when $\epsilon = 4 - d \to 0$, and therefore they cannot be obtained by the ϵ-expansion method. The arrows on the trajectories show the direction of motion on decrease of τ. Plotted as heavy lines are the separatrices, which bound the region of stability of the fourth limiting point. The occurrence of a stable fixed point means that the corresponding phase transition is a transition of the second kind. It is easy to find also the critical indices. In particular, the index of the susceptibility $\gamma \approx 1.7$.

The fact that, experimentally, transitions from a isotropic liquid into a nematic liquid crystal are of first order close to the second can be due to two reasons. Either the parameters of the initial Hamiltonian (1) lie outside the region of stability of the fourth fixed point, or this fixed point is unstable with respect to weak interaction of the order parameter with some degrees of freedom not taken into account here (for example, elastic ones). In both cases, the region of "collapse" of the second-order transition to one of the first may be very narrow.[5] Therefore the strong divergence of the susceptibility ($\chi \sim \tau^{-\gamma}$ with $\gamma \approx 1.7$), corresponding to the fourth limiting point, can be detected, for example, in experiments on light scattering.

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