Some Peculiarities of the Pre-Transitional Behavior of the Relaxation Time of Order-Parameter Fluctuations in the Isotropic Phase of Nematic Liquid Crystals

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The transition from an isotropic liquid to a nematic liquid crystal (IN) is a weakly first-order phase transition, and many properties of the isotropic phase display critical behavior while approaching the transition temperature. Pre-transitional phenomena in the isotropic phase of liquid crystals are related to the existence of correlations in the orientation of the long axes of molecules at a distance, which is significantly higher than intermolecular ones. In the near vicinity of IN, the isotropic phase is characterized by developed fluctuations of the orientational order parameter with strong spatial correlations.

The applicability of Landau – de Gennes (LdG) theory (mean-field approximation) for the description of static and dynamic properties of the isotropic phase has been successfully confirmed by numerous experiments on magnetic and electric birefringence, light scattering intensity, dynamic light scattering, optical Kerr effect, and nuclear spin-lattice relaxation.

In this work, we studied the frequency distribution of intensity in scattered light spectra (depolarized scattering) in the isotropic phase of nematic liquid crystals MBBA and PAA in a wide range of temperatures, in order to investigate the temperature behavior of the relaxation time of order-parameter fluctuations. The spectra were registered with the help of a high-resolution spherical Fabry-Perot interferometer. To determine the range of applicability of LdG theory, we determined the temperature of the second-order phase transition from the temperature behavior of the inverse integral intensity of scattered light.

The experimental results showed that when the correlation length of order-parameter fluctuations falls below 3 molecular lengths, the isotropic phase of liquid crystals starts to make a transition from a locally ordered liquid to a simple liquid. This magnitude appears to be a minimal correlation length of order-parameter fluctuations for which the LdG theory is valid, and collective features of the behavior for kinetic variables of the isotropic phase are preserved.