Liquid-crystalline photonic crystals in particular cholesterics and Blue Phases [1] constitute a class of structures with unique optical properties. In spite of a long history of studies, many features of photonic liquid crystals are still unclear. One particular example is the interconnection of macroscopic properties of the photonic structure with microscopic and macroscopic characteristics of the liquid crystal. Another important question is the possibility to describe temperature-induced transformations of photonic properties employing the models of phase transitions. In this work, we report the results of our investigations of photonic liquid crystals.

Spectra of diffraction, transmission, rotation of the plane of polarization of light were measured on high-quality samples of different liquid crystalline photonic crystals. Oscillations in spectra of rotation of the plane of polarization of light predicted by theory were observed. These peculiarities are related to Pendellosung oscillations. Analysis of the spectra is performed on the basis of the solutions of Maxwell equations and fundamental Kramers-Kronig relations [2]. Temperature dependence of the spectral position $\nu_0$ and width of the photonic stop band $\Delta \nu$ of the cholesteric photonic crystal was determined. In samples with rigid boundary conditions, in addition to the well known stepwise change of the position of the diffraction bands with temperature, the spectral widths of the diffraction band and of the photonic stop band also undergo stepwise transitions. It is shown that the temperature dependence of the relative width of the photonic band $\Delta \nu/\nu_0$ can be described by Landau theory of first-order phase transitions. Parameters entering the model were obtained. The results enable to determine molecular susceptibility of the liquid crystal. We utilize the experimental data to reconstruct the temperature dependence of the orientational order parameter. Comparison of our data with the results for nematic liquid crystal shows good agreement. The results of our investigations demonstrate the applicability of universal approaches for the description of different properties of liquid-crystalline photonic crystals.

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References: