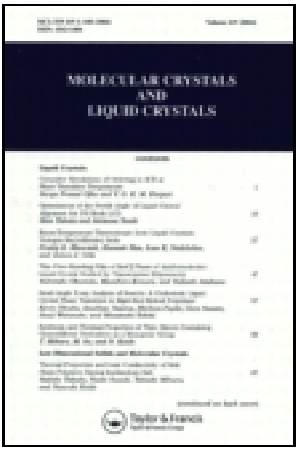

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Harmonic Distortion of the Induced Helical Structure of the Nematic Liquid Crystal Detected by the Distributed Feedback Laser

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HARMONIC DISTORTION OF THE INDUCED HELICAL STRUCTURE OF THE NEMATIC LIQUID CRYSTAL DETECTED BY THE DISTRIBUTED FEEDBACK LASER

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Abstract Helical structure induced in nematics by non-mesogenic optically active dopants (OAD) was studied by means of the distributed feedback laser (DFL) spectroscopy. A difference was found between laser generation frequencies and Bragg frequencies of theselective transmission spectra, attributed to thepresence of two sublattices in the induced helicalstructure due to its distortion.

Development of the distributed feedback lasers (DFL) is a promising application of cholesteric liquid crystals (LC) in quantum electronics. The DFL active elements are planar thin cholesteric layers activated by generating dyes. The first DFLs using cholesteric liquid crystals which allowed temperature control of the generation frequency and optimization of the generation characteristics were reported (Refs[1-3]). Some technological drawbacks of conventional steroid-based cholesterics (high viscosity, difficulty in preparing mixtures with wide temperature ranges, etc.) make it necessary to look for other LC materials for the DFLs.

The aim of the present paper was to study possibilities of developing DFL based on the helical structure induced in nematics by non-mesogenic OAD.

Eutectic **mixtures** based on cyanobiphenyls (ZhK-1282) and MBBA were used as nematic matrices, and 2-(4'-phenyl-benzylydene)-1-menthane-3-one as a twisting dopant (8-9 wt.%). The mixtures were activated by 0.5 wt.% of a phenalenone generating dye. A 15-30 μm thick layer of the induced cholesteric mixture between glass substrates covered with rubbed layers of polyvenyl alcohol,**forming the planar texture, was prepared.** Selective transmission (ST) spectra of LC and fluorescence of the dye were monitored by SF-10 spectrophotometer and MDF Hitachi spectrometer. Both devices had spectral resolution of 0.5 nm. Excitation of the LC cells was carried out at the angle of 20° to the substrates normal using the second harmonic radiation of Q-switched Nd^{3+}-glass laser (λ=0.53μ) in the **single-pulsed regime;** maximum laser beam intensity was 8 mW cm^2, beam diameter in the plane of LC layer was 0.5 mm.

Generation spectrum in both cases (induced helicity and cholesterol derivatives[3]) consists of three lines with the central one (with lower threshold) corresponding to the Bragg wavelength (λ_{Br}) ,and the side ones-to the higherindex longitudinal modes. There is one peculiarity in the induced helicity spectrum. Unlike that of cholesterol derivatives, the central line of the triplet does not coincide with λ_{Br} in Ref[4].

Fig.1 shows the transmission spectrum of the doped ZhK-1282 for the linearly polarized light and fluorescence spectrum of the impurity dye. At the OAD content of 8.12 % (curve 1), the principal generation line with the threshold 150 kW/cm^2 is λ_g= 582.4 nm,

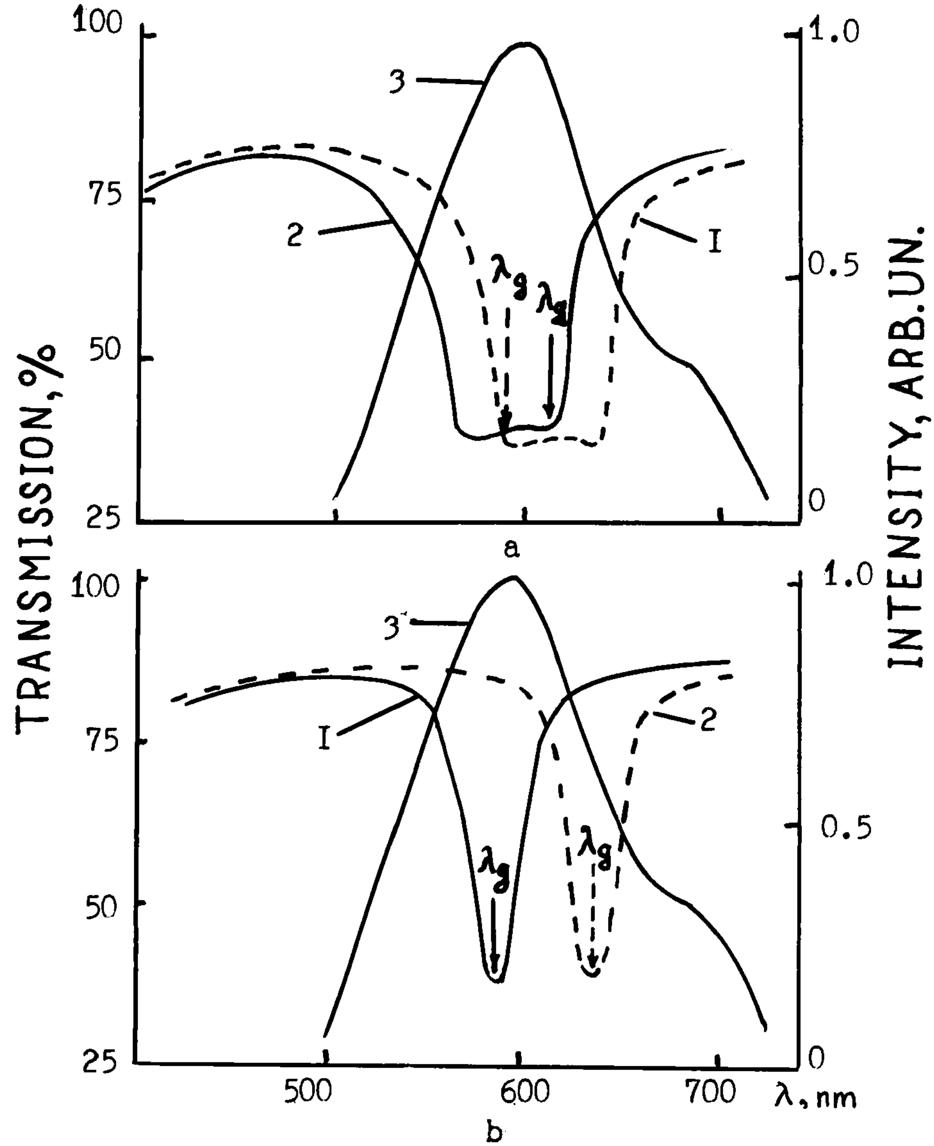

FIGURE 1, a-position of SR band and λ of the DFL generation for different of the OAD concentrations. 1-c=8.12%, 2-c=9%; b-the same for different cholesteryl chloride concentrations in the ternary mixtures. 1-32%, 2-36%. 3-amplification spectrum of the dye used.

whereas λ_{Br} determined from the SR Spectrum is equal to 624 nm. On increasing the OAD content to 9 % the SR band shifts to the short wavelength edge of the spectrum (curve 2) and λ_{Br} becomes equal to 580 nm. The mean DFL wavelength at this OAD content and at the constant temperature (21°) is equal to 605 nm, and it corresponds to the long wavelength edge of the SR band.

It was noted earlier[1] that for DFLs based on conventional (steroid) cholesterics temperature changes of the helical pitch cause λ_g and λ_{Br} to converge (within the measurement errors, ± 0.5 nm). Fig. 1b shows the SR spectrum of a three component cholesteric, mixture (cholesteryl pelargonate, oleate, and chloride) for different cholesteryl chloride concentrations. It can be seen that for DFL based on cholesterol derivatives the concentration-induced helical changes cause λ_g and λ_{Br}.

Generation of DFL based on the mixture of MBBA doped with the same OAD (7-8 %) gives rise to λ_{Br} in the range of 580-620 nm, and is similar in character.

Thus generation characteristics for the opposite edges of the SR band in cholesterics with the induced helicity and the behaviour of spectrum for the nondiffract polarization suggest non-uniform broadening of the SR band and presence of at least two sublattices in such a structure. Under the stimulated radiation conditions, there is a possibility to separate the contributions of the two lattices to the concentration-induced shift of the SR spectrum within the dye amplification band. Generation is caused by the lattice for wich λ_{Br} lies in the range corresponding to stronger dye amplification.

The results obtained may be understood in terms of harmonic distortions of the helical twisting axis resulting from a combined elastic strain. Under tangential boundary conditions, the combined elastic strain implies a screw coiling of the helical twisting axis[5] with a pitch close to that of intrinsic twisting of LC director **n** (Ref.[6]). In this model unlike the De Vries[7] structure quasinematic laers, are not parallel but are, in addition to twisting, inclined by the angle φ to the substrate planes, with φ varying periodically from 0^{o} to φ_{max}. Diffraction on quasinematic layers which are parallel to the substrate and on those which are inclined at the maximum angle φ may be the cause of the existence of two different generation frequencies at the SR band edge. Assuming that, the maximum inclination angle can be estimated as $\varphi_{max}=24^{o}$ (Ref.[6]).

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