Anharmonicity of Cholesteric Helix: a New Insight on Photonic and Electro-optical Properties

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Using numerical simulations and the results of our experiments we discuss behaviour of a defect free cholesteric liquid crystal in rather a strong electric field. The smooth helix unwinding predicted by de Gennes [1] occurs under the thermodynamic equilibrium conditions [2] and can easily proceed with the assistance of multiple defects. However, a defect free helix in the field strictly perpendicular to the helical axis cannot be unwound for topological reasons [3]. The field deforms the helix *without a change of its period* (helix wavevector q_0=const) and induces higher harmonics of the helical structure. The symmetry of such an experiment results only in *odd* harmonics of the helical structure.

We are mostly interested in the light propagation along the helical axis. Due to the helix distortion, the shape of the fundamental (Bragg) stop-band is changed and higher order photonic stop-bands appear. Particularly, the presence of the third harmonic in the helical structure allows for the second ($k_0=2q_0$, $\lambda=\langle n\rangle P_0/2$) and third ($k_0=3q_0$, $\lambda=\langle n\rangle P_0/3$) optical bands centered at the double and triple Bragg frequency, respectively. It is interesting that the second photonic band is a result of optical mixing the 1st and 3rd harmonics of the distorted helix.

The second-order photonic band is observed in the optical transmission. Moreover, novel laser effects are predicted by modelling dye-doped, distorted cholesteric liquid crystals. The same field-induced anharmonicity results in a strong change of the polarization state of the beam passing the helical structure along its axis. This effect is observed at low voltages. Due to fast relaxation of higher harmonics, the switching time of the devices using the corresponding electro-optical effect (called In-Plane Switching) can be improved significantly ($\tau \propto m^{-2}$, m is harmonic number). This is shown both experimentally and by numerical calculations [4].

[1] P. G. de Gennes, *Sol. State. Commun*. **6**, 163 (1968).
[2] R. B. Meyer, *Appl. Phys. Lett*. **14**, 208 (1969).
[3] S. P. Palto, L. M. Blinov, *J. Soc. Elect. Mat. Eng*. **14**, 115 (2005).
[4] S. P. Palto *et al* (this conference).