Magnetic Field-Controlled Light Transmission in Ferronematic Liquid Crystals

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1. Introduction

Ferronematic liquid crystals (FNLC) are characterized by combination of the orientation structural ordering of the anisotropic (nematic) molecules with the magnetic ordering of magnetic nanoparticles, arched by interphase interaction with the nematic molecules. The strong effect of an external magnetic field on an orientation ordering molecular structure (describing by the nematic vector,) occurs indirectly via its interaction with magnetic moments of nanoparticles. The mentioned indirect effect of the magnetic field on the molecular orientation is several orders of magnitude more than the direct influence via the molecular diamagnetism [1-2]. The magnetic field-induced change of the nematic director is accompanied by a corresponding change of the optical axis coinciding with it. This is manifested in the magneto-optic effect of the polarization twisting and the large birefringence of linear polarized light passing through the FNLC. The transmission of the linearly polarized light through the FNLC sandwiched by two crossed polarized is characterized by the dependence of the transmitted light intensity on the applied magnetic field, that can be important applications in displays and photonics.

2. Methods

The magneto-optic effect of the dependence of the intensity of a linearly polarized linear polarization laser light transmitted through the ferronematic liquid crystal magnetic on the applied external field is described on the basis of the equations of the variation problem for the functional of the free energy density of FNLC and the equations describing the phase change of the laser light under an applied magnetic field. Magneto-induced change of the polarization vector in the laser light is modeled within the Jones matrix formalism. Measurement of the magneto-optic effect in the FNLC is based on the experimental set-up presented in Fig. 1.

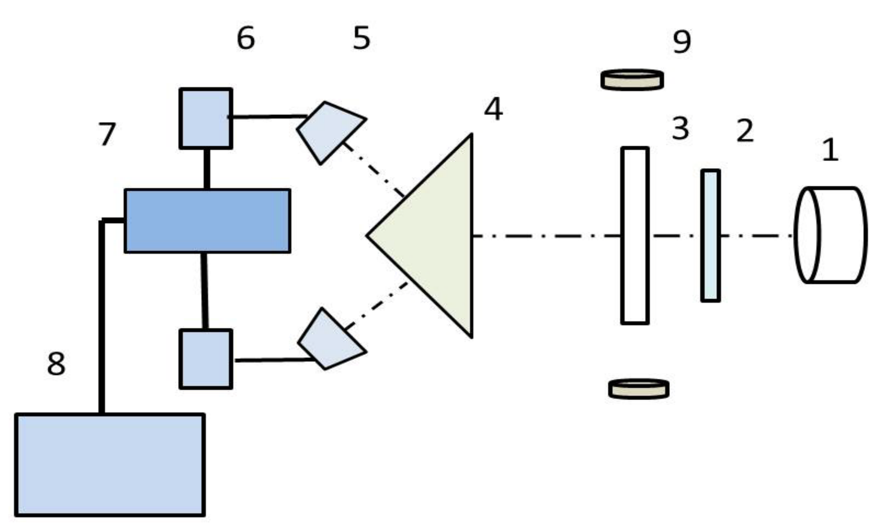

Fig. 1.

Fig. 1. The experimental set-up for measurements of characteristics of the magnetically sensitive FNLC with ferromagnetic nanoparticles: 1 - semiconductor laser, 2 - polarizer, 3 - FNLC sample, 4 - polarization prism Senarmon, 5 - two photodetectors, 6 - two amplifiers, 7 - two-channel analog-digital converter, 8 - personal computer, 9 - Hemholtz coils.

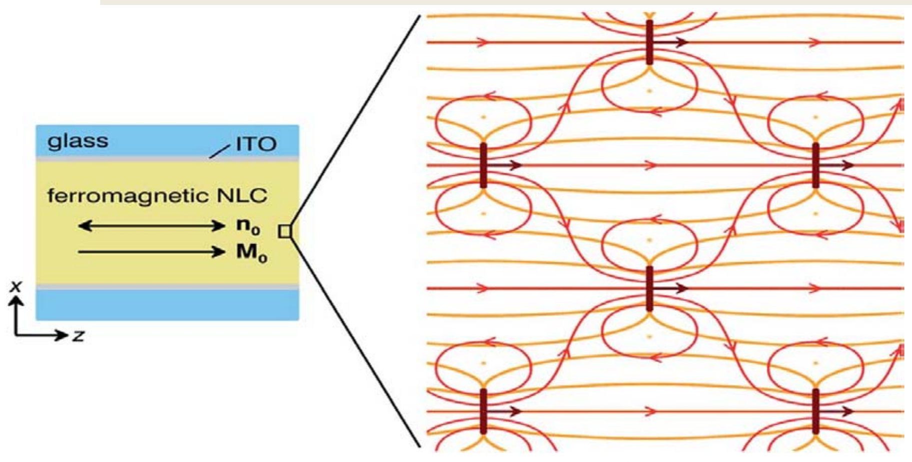

Fig.2.

Fig. 2. A schematic of a FNLC cell (left) and the microscopic structure of the ferromagnetic suspension (right). Glass plates (blue) have ITO electrodes (gray). In the absence of an external field the average macroscopic director **n** and magnetization **M** are homogeneously oriented in the plane of the cell.

3. Results

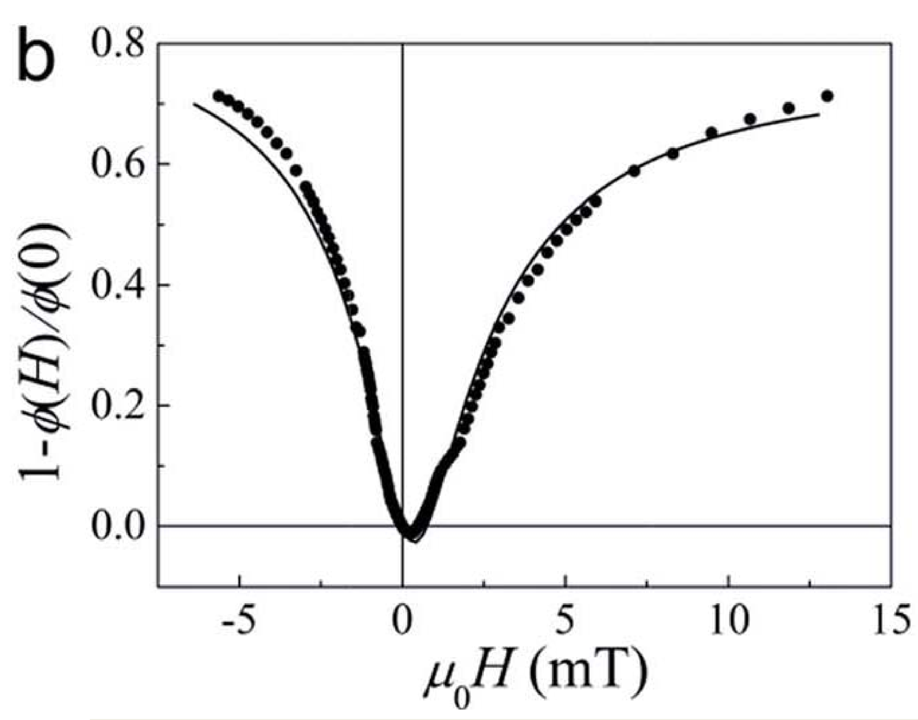

Fig. 3. Magneto-optic effect in a transverse field. Normalized phase difference vs. external magnetic field H.

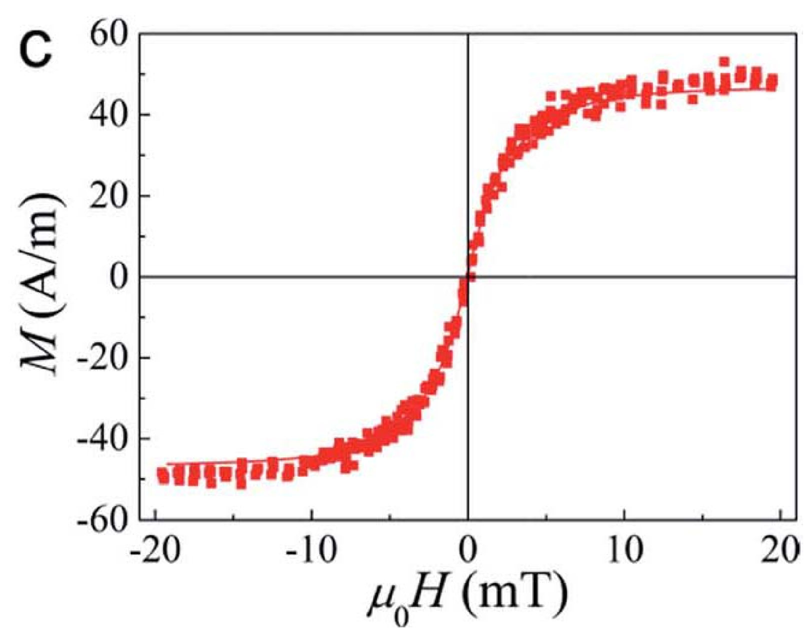

Fig.4. Magnetization curve of the FNLC.

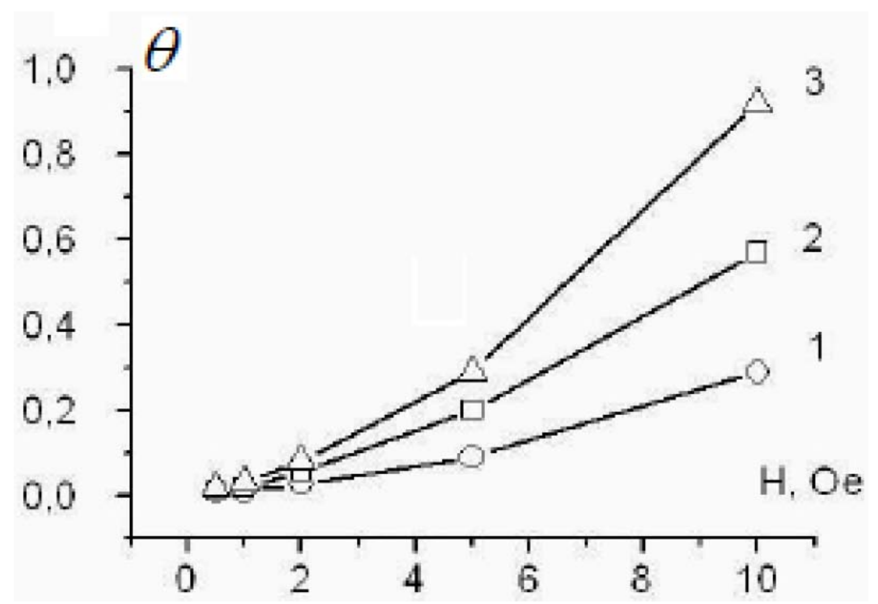

Fig. 5. Dependence of the angle of the nematic director rotation on the applied magnetic field (1– H=1 Oe, 2– 10 Oe, 3– 20 Oe).

$\mathbf{E}=E\,\mathbf{j}\exp(\mathbf{kr}-\omega t)$ - an electric field **E**, which is linearly polarized after the laser light passes through the polarizer.

$\phi = k \int [n_e(z)-n_o]dz$ – the phase difference of the transparent laser light (n_e and n_o – the extra- and ordinary refractive indices); $r=1-\phi(H)/\phi(0)$ – the normalized phase difference induced by the applied magnetic field.

Acknowledgement

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3. References

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