Three-Dimensional Non-destructive Imaging of the Director Field

Oleg D. Lavrentovich

Chemical Physics Interdisciplinary Program and Liquid Crystal Institute,
Kent State University, Kent, Ohio 44242; odl@lci.kent.edu; www.lci.kent.edu/Lavrentovich

Understanding the three-dimensional structure of the director field is of prime importance for the development of high-quality displays and other devices based on liquid crystals. Non-destructive techniques to study how the director changes in response to the applied electric field, surface properties, size of the pixel, etc., are in a great demand. Most of the available techniques, such as optical polarizing microscopy, produce only an integrated two-dimensional (2D) image of the 3D structure, integrating the 3D pattern of optical birefringence over the path of light.

We describe a non-destructive technique, called the fluorescence confocal polarizing microscopy (FCPM) that is capable to visualize the 3D patterns of director in a variety of liquid crystal cells [1, 2]. We employ the property of anisotropic media to align fluorescent dye molecules. In polarized light, the measured fluorescence signal is determined by the spatial orientation of the molecules. The amount of dye needed to obtain a high-contrast image is very small, about 0.01 wt. %. The FCPM technique literally adds a new dimension to the studies of liquid crystals and electrooptic effects in them by revealing how the orientation of molecules changes not only in the plane of observations, but also along the direction of observation.

We illustrate the method with different systems, including the field-induced director reorientation in the nematic liquid crystal [1, 2], surface-dislocation interaction in lamellar liquid crystals [3] and phase separation in distorted liquid crystal-polymer mixtures [4].

This work was supported in part by the donors of the Petroleum Research Fund, administered by ACS, 35306-AC7.

1. I.I. Smalyukh, S.V. Shiyanovskii, and O.D. Lavrentovich, Chem. Phys. Lett. **336**, 88 (2001).
2. S. V. Shiyanovskii, I. I. Smalyukh, and O. D. Lavrentovich, Chapter in Defects in Liquid Crystals: Computer Simulations, Theory and Experiments, **43**, p.229. O. D. Lavrentovich, P. Pasini, G. Zannoni, S. Zumer (eds) (NATO Science Series, Kluwer Academic Publishers, 2001).
3. I.I. Smalyukh and O.D. Lavrentovich, Phys. Rev. E **66**, 051703 (2002) and Phys. Rev. Lett. **90**, 085503 (2003).
4. D. Voloschenko, O.P. Pishnyak, S.V. Shiyanovskii, and O.D. Lavrentovich, Phys. Rev. E **65**, 060701 (2002).