Fluorescence confocal polarising microscopy imaging of micro-spheres in liquid crystals

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Traditionally, optical imaging of liquid crystal structures has been limited to the use of a polarising microscope to obtain a single integrated image of the transmitted or reflected light. More recently, optical waveguide characterisation techniques have provided a highly sensitive means of probing the director structure within a liquid crystal cell varying in one-dimension [1, 2]. However, the resolution in the plane of the substrate is limited to the diameter of the probing laser beam and is still much bigger than the length scale required to quantify the liquid crystal alignment on micro-sculptured surfaces.

In fluorescence confocal polarising microscopy (FCPM) [3] the liquid crystal structure under study is doped with a high quantum yield fluorescent dye composed of elongated molecules with the transition dipole of both the excitation and fluorescence assumed to be along the long-axis of the molecule. The dye absorbs strongly at one wavelength and emits at one of a higher value and is added in a low concentration to a liquid crystal host. The molecules orientate parallel to the liquid crystal molecules, mimicking the director distortion through a cell. A beam of polarised light at the excitation wavelength is focussed into a small volume ($<1\mu m^3$) in the sample. For a linearly polarised excitation beam the efficiency of the light absorption of the dye and detection of the fluorescent emission is controlled by the angle between the polarisation axis of the incident light and the absorption axis of the dye molecule. This efficiency is recorded as a variation in the intensity of light detected, and from this the orientation of the director can be deciphered. By scanning in the x-y plane at a fixed depth z, an optical "slice" is recorded, and by repeating this at further distances through the cell, a 3D model of the director orientation can be produced.

In this study, the FCPM technique is used to explore how the presence of micro-particles in a liquid crystal host perturbs the director alignment. Specifically, a parallel-aligned liquid crystal is used as the host medium, allowing the influence of the embedded micro-spheres on the alignment structure to be observed. Preliminary images will be presented, along with a discussion of the issues governing the deconvolution of these images and factors limiting the performance of the imaging technique.

References:

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