Optical Properties of exotic defect structures in a strongly confined cholesteric blue phase liquid crystal

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Some of highly chiral liquid crystals exhibit cholesteric blue phases [1], known as exotic three-dimensional ordered phases made up of an intricate network of topological line defects of orientational order (disclination lines), and so-called double-twist cylinders in which the orientational order is twisted along all the directions perpendicular to the cylinder axis. They have attracted interest of physicists as intriguing frustration-induced order, and for this decade they have been drawing greater attention as a possible candidate material for next-generation fast-switching display.

In our previous numerical studies, we showed that when a chiral liquid crystal exhibiting cholesteric blue phases in the bulk is confined between two parallel substrates, one can observe various defect structures not found in the bulk, depending on the thickness of the confinement, anchoring conditions (homeotropic or planar) and temperature. These structures include a hexagonal lattice of Skyrmion excitations, a regular parallel array of disclination lines of double-helix form, and an array of four-arm junctions of disclination lines as seen in bulk blue phase II.

In this work, we investigate the optical properties of these exotic defect structures exhibited by a chiral liquid crystal. To be more specific, we calculate the profiles of the reflected and transmitted light when a monochromatic light is incident normally onto the liquid crystal [3]. Our numerical calculations are based on plane-wave expansions. In the lateral direction, the electromagnetic waves are expressed as Fourier expansions, and along the normal direction finite-difference discretization is employed inside the liquid crystal. We particularly focus on the reflected light and show that the intensity profiles depend crucially on the structure of the liquid crystal, and the wavelength and the polarization of incident light. Our exotic defect structures found in a thin cell of a chiral liquid crystal could be used as tunable optical gratings and we hope our present study will elucidate how they work.

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References:

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