Tunable multicolored patterns from photonic cross communication between cholesteric liquid crystal droplets

J.H. Noh1*, H.-L. Liang2, I. Drevensek-Olenik3 and J. Lagerwall4

1 Seoul National University, Graduate School of Convergence Science & Technology, Suwon, South Korea
2 Institute of Organic Chemistry, Johannes Gutenberg University Mainz, Germany
3 University of Ljubljana, Faculty of Mathematics and Physics, and J. Stefan Institute, Ljubljana, Slovenia
4 University of Luxembourg, Physics & Materials Science Research Unit, L-1511 Luxembourg, Luxembourg

Short-pitch cholesteric liquid crystals are exquisite soft photonic materials with attractive optical properties. While they have been extensively studied and applied in flat sample geometries, a new focus has arisen recently, targeting drops or shells. This research attracts much attention as it puts the spotlight on peculiar phenomena arising when the helically modulated cholesteric phase is curved into spherical shape, and as a number of potential novel applications have been identified that take advantage of these properties, e.g. omnidirectional lasers [1-3]. Here we focus on the unique type of optical communication taking place between adjacent cholesteric droplets, giving rise to intriguing and attractive patterns.

With a glass capillary microfluidic set-up, we produce droplets of cholesteric liquid crystal mixtures, tuned to reflect light in the visible range. The monodisperse cholesteric droplets are collected at high volume fraction in a planar container, forcing the droplets to spontaneously arrange in a 2D colloidal crystal arrangement. Planar director alignment is ensured by adding polyvinylalcohol (PVA) to the aqueous continuous phase. This leads to a radial helix orientation within the droplets which thus exhibit selective reflection in all directions.

Hexagonally close-packed droplets exhibit colorful patterns with six-fold symmetry, see figure below. The center of each droplet is decorated by a spot that corresponds to normal incidence selective reflection. Along the perimeter appears a regular pattern of spots that are blue-shifted compared to the central spot. To find the origin of the multicolored appearance, we explore the patterns dynamically by varying the size of illumination using the field aperture of the microscope. As the illuminated area is gradually expanded, spots appear in specific sets, reflecting photonic communication between droplets [4]. This communication can be direct, from droplet to droplet, or it can be mediated via total internal reflection at the surface of the continuous phase. Apart from the fundamental optical perspective, the observations reveal application potential in e.g. sensors or anti-counterfeiting tags.

Cholesteric droplets in hexagonal close-packed colloidal crystal arrangement, observed in reflection polarizing microscopy. The pitch of the cholesteric mixture used decreases from left to right, with infrared normal incidence reflection on the far left and green normal incidence reflection on the far right.

References:

* presenting author; E-mail: junghyun719@snu.ac.kr