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Topological Defects, Symmetry Breaking, Self-Assembly, Structure Formation in Soft Matter

Topological defect arises when the symmetry of order in material is broken. The symmetry breaking can be induced by phase transitions or by application of confinements. The types of defects, such as point, line, or walls, depends on dimension of the order and topology of the confinement. Though topological defects represent the corruption of the previous order, they trap molecules and particles. The network between defects provide a scaffold, or the attraction between defects triggers the self-assembly and holds the inclusions together. Periodic, regular, stable topological defect network mediates the birth of a new order. The dynamics and mechanism of defect network formation explain why and how colloids, biological fibers, and tissues grow into a particular structure.

To observe and analyze the "crystal of defects" systematically, topological defects are generated in liquid crystal and arranged in square or hexagonal arrays. The topological charge and shape of the defect can be assigned by the delicately designed pattern of the electrodes. Selection rules of stable defect array are discovered or derived on the basis of symmetry, topology, and field theories.

The defect array shows artistic visual effects, which is a mixture of lensing, diffraction, and haze. They are topologically protected, self-retained, and self-healing. Therefore, they are promising templates for self-assembled wires, fibers, photonic crystals, or tissues. The study will reveal the physics behind the natural growth and forms.

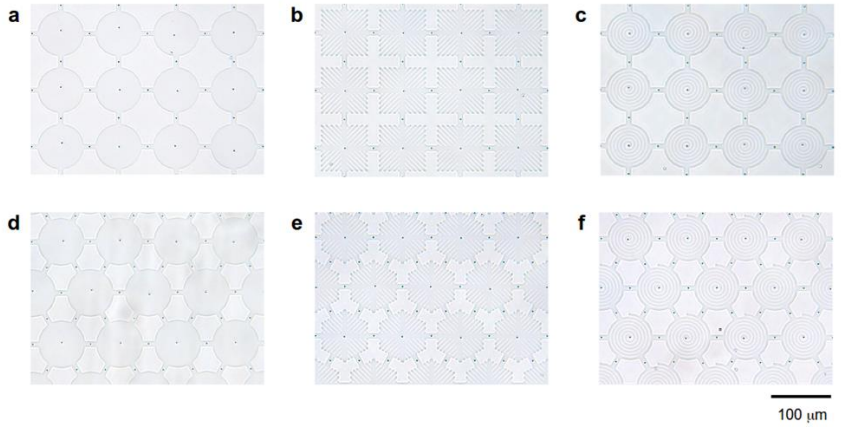

Figure 1 Array of point defects under optical microscope. Point defects (the black spots) in liquid crystal were generated by patterned ITO. (a) Pad pixel in square lattice. (b) Fishbone pixel in square lattice. (c) Coil pixels in square lattice. (d) Pad pixel in hexagonal lattice. (e) Fishbone pixel in hexagonal lattice. (f) Coil in hexagonal lattice.

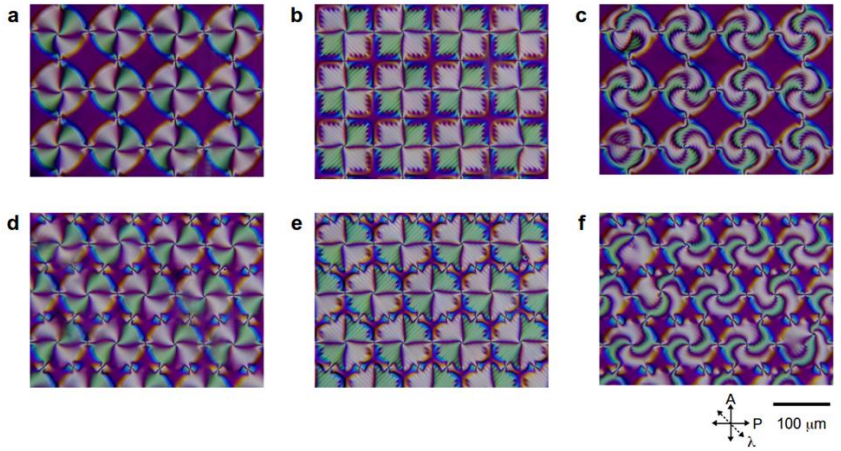

Figure 2 Array of point defects under polarized optical microscope. Crossed polarizers on 0° and 90°. A λ-wave plate was placed on 135°, so the directors lying in 45° and 135° show lime and pink, respectively. (a) Pad pixel in square lattice. (b) Fishbone pixel in square lattice. (c) Coil pixels in square lattice. (d) Pad pixel in hexagonal lattice. (e) Fishbone pixel in hexagonal lattice. (f) Coil in hexagonal lattice.