

Master 2 Internship

Title: Real-time imaging of 3D vectorial topologies in liquid crystal

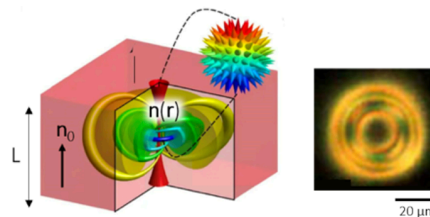
Type: experimental

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PhD funding (if any): yes

Project: Understanding how topological structures emerge, evolve, and can be transferred between physical systems is a central question in modern physics. Recent advances in frustrated chiral liquid crystals have shown that bulk systems can spontaneously host non-trivial 3D topological configurations¹. These structures arise from the helical ordering of the director field $\mathbf{n}$ across a thickness L , and they can be observed experimentally using polarized optical microscopy, as illustrated in the figure. Such soft condensed matter systems provide a controllable and versatile platform to study topological textures in matter that is far easier to implement experimentally than one can do in solid-state condensed matter systems such as magnetic materials.



Frustrated chiral liquid crystals slabs with helical ordering of the director field $\mathbf{n}$ is about the thickness L of the slab exhibit three-dimensional localized topological structures in bulk systems: sketch and experimental observation of a liquid crystal Hopfion via polarized optical microscopy.

In our group, we have developed an expertise to optically write & erase topological structures in liquid crystals, in a directional manner with respect to various degrees of freedom of light (polarization, phase, amplitude).¹ In this regard, understanding the morphogenesis process remains a challenge that we propose to address by developing a novel optical imaging technique based on undisclosed yet preliminary experimental proof-of-principle.

Concretely, the developed technique will provide direct, real-time access to all three spatial dimensions, in striking contrast to existing techniques, which require tedious three-dimensional reconstruction from point-by-point scans acquired by nonlinear optical microscopy². This capability will enable the investigation of the dynamics and topology of liquid crystal textures and defects, as well as phase transitions and nucleation processes, in fundamentally new ways. In brief, the student will develop the experimental setup, perform experiments (e.g., spatio-temporal polarimetry and pump-probe experiments) and analyze the data.

Hence Master 2 intern will develop expertise in polarization optics, light-matter interactions, and liquid crystal physics with an opportunity to pursue the project with a PhD.

¹ Bruni, N.; Loussert, C.; Rafayelyan, M.; Orlova, T.; Coursault, D.; Brasselet, E. Rewritable Binary Recording of the Photon Spin State in Chiral Liquid Crystals. *Phys. Rev. Lett.* **2025**, *134* (22), 223804.

² Lee, T.; Senyuk, B.; Trivedi, R. P.; Smalyukh, I. I. Optical Microscopy of Soft Matter Systems. In *Fluids, Colloids and Soft Materials*; John Wiley & Sons, Ltd, 2016; pp 165–185.