Postdoctoral application in soft matter physics

Liquid crystals with a twist

Physical design, optical properties and applications in biomimicry

In brief

We seek a highly motivated applicant interested in questions about the research topics "Physics of chiral cholesteric liquid crystals: design, optics and structure" and "Biological liquid crystals with their biomimetic versions".

The experimental methods include a strong effort in the physical design of cholesteric samples with a complex twist by soft matter methods, associated with spectrophotometry, advanced optical microscopy and image analysis.

The principal supervisor, Michel Mitov, CNRS Research Director, leads the research subject, which brings together concepts from soft matter science, liquid crystal physics, optics of chiral liquid crystals, biological cholesterics, and biomimetic liquid crystals. The topic addresses the link between the optical features and structure of designed materials as disclosed by complementary microscopy (SEM, TEM, AFM). As a member of the *Complex Photonic Materials and Systems* team, the post-doctoral researcher will benefit from the expertise of researchers who specialize in ultrafast optics, nanophotonics, and the physical properties of optical materials developed to meet the challenges of modern photonics.

Research field

Cholesteric liquid crystals (CLCs) have a chiral, twisted structure. They selectively reflect light and the reflection wavelength is related to the helix pitch. The reflected light is circularly polarized with a sense, left or right, identical to the sense of the helix. Wavelength, from UV to IR, and polarization, from circular to elliptical, vary with viewing angle. CLCs have many applications in the field of pressure, chemical and temperature sensors, reflective polarizer-free screens, optical elements to diffract, reflect, scatter, and redirect light, from the mesoscopic scale to the nanoscale. The cholesteric structure is a common architecture in the animal and plant kingdoms, by concerning the organization of macromolecules and biopolymers essential to life such as DNA and chromatin, collagen, cellulose and chitin.

Complex twisted architectures may be designed by the physical elaboration of cholesteric films whose structure includes the in-volume modulation of the helix pitch, the curvature in the orientation of the helix axis or the presence of two senses of helicity in one and the same material. These structures should be sought using a generic design that mobilizes the physical parameters such as molecular anchoring, surface tension and its anisotropy at interfaces, film shaping (planar state, spheres and shells, in a rigid or flexible capacitive cell, or at the self-suspended state, etc.) rather than specific chemical synthesis. This strategy of the team underpins ongoing research endeavors in the field. The interest of such structures is at least twofold: to obtain unusual optical properties such as the modulation of the Bragg band or the encryption of optical data within a single and homogeneous film;

to mimic natural twisted structures like those of the chitinous, iridescent carapace of beetles, for optical communication and IR thermoregulation purposes.

For further information about the field, the applicant may visit the website of the Liquid Crystals for Optics thematic and the publications of the supervisor, including pedagogical reviews articles, and a summary of the most recent COLEOPTIX contract from *Agence Nationale de la Recherche*, for which he served as coordinator.

Goal of the project

The visual system of some fish distinguishes changes in color and polarization. CLCs selectively reflect light. Wavelength, from UV to IR, and polarization, from circular to elliptical, vary with the angle of observation. The supervisor's hypothesis is that fish could use this versatility of the reflective patterns of their cholesteric collagen scales to move collectively and reorient themselves with remarkable speed within a school. In a unique biomimetic approach, the objective is to develop reflective optical tags inspired by these biological structures in relation with the optical reading of the images coded in the tags. The subject has a strong experimental component and is interdisciplinary in nature. This involves correlating the physical characteristics of the tags in close connection with the determination of the chiro-optical properties of the reflected wave.

Role of the post-doctoral researcher

The post-doctoral work's will consist of creating artificial versions comprising singular twisted structures with a: non-monotonous pitch; variable orientation of the axis of symmetry; double helicity; combination of several of these geometries. This development work will be accompanied by the study of the optical properties of biomimetic films and their small-scale structure, by electron or near-field microscopy in collaboration with experts in the field.

Targeted skill acquisition

At the end of her/his post-doctoral period, the researcher will be able to master the full chain: design of optical films of complex-twisted liquid crystals, elucidation of their chiro-optical properties and their structure determined by different microscopy techniques, by himself and in relation with specialists in the field. Depending on the progress of the research work, the activity may extend to prototyping in conjunction with researchers specializing in optical sensors and robotics. The research project is a multi-faceted research topic, the results of which could lead to an applied and topical problem, that of guiding a fleet of autonomous vehicles, with strong potential for valorization in academic and industrial circles.

Your profile

The applicant must be strongly interested about experimental work and possess tenacity. (S)he will be autonomous and communicative, combining curiosity with a thorough education in physics, physical chemistry, or materials science. Prior knowledge and experience in soft matter physics or chemistry are solid assets. Knowledge in liquid crystal science is welcome but not required (the supervisor will provide the appropriate training). Prior quantitative research methods and practical work in labs would be beneficial. Good knowledge and understanding of materials physics and chemistry, including polarized light optics, spectrophotometry, and light–matter interactions are assets.

Our offer

Duration: 12 months (extendable period).

Work hours: Full time (35.0 Hours per week).

The earliest starting date for this position is Oct. 01st, 2024.

Salary : according to profile

The supervisor is the recipient of financial support from Université Côte d'Azur, IDEX Academy of Excellence *Complex systems – France 2030*, for project activities and related missions, including those of the postdoctoral researcher. The goal of this academy is to create spaces for intellectual exchange to enable the emergence of new ideas and support innovative, original and quality projects that have an impact on the national and international research landscape.

The CNRS is the French National Center for Scientific Research that pursues research that leverages every field, in pursuit of sustainable progress, to deliver technological, scientific or societal advances.

The Institut de Physique de Nice (INPHYNI) is composed of 11 research teams organized along three axis: Waves and Quantum Physics; Photonics; Nonlinear Physics, Complex Fluids and Biophysics.

The deadline to apply is 15th June 2024 but may be closed in advance as soon as an applicant corresponding to the expectations of the position would be selected. Applicants who have decided to apply are advised to do so without delay.

Your application

Applications should include a CV, a list of publications, contact information of two referees, a link to the pdf version of the PhD thesis, and a statement of interests about the present proposal.

Please send your application, or any inquiry, by email to michel.mitov@univ-cotedazur.fr in one pdf-file.