Master 2 Internship

Title: THz vortex beams: generation and macroscopic optical angular manipulation

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Project:

An electromagnetic wave is defined by its amplitude, carrier frequency, wave vector and angular momentum. The latter can be decomposed into two distinct terms: the spin angular momentum (SAM, describing the polarization state of the wave) and the orbital angular momentum (OAM) associated to the spatial distribution of the electric field. Generally, an electromagnetic wave with OAM can be characterized by an azimuthal dependence of its phase like $\exp(-il\theta)$, with l an integer called the topological charge. A beam possessing such a spiral phase distribution is called a vortex beam and carries a $l\hbar$ OAM per photon.

Geometric phase optical elements represent a powerful pathway to generate structured light - especially optical vortex beams - driven by the photon spin. However, the efficiency of current devices is inherently restricted to selective spectral lines due the chromatic nature of the physics at work. We recently initiated THz vortex optics in France by direct beam shaping in the THz domain [1] and by spectral transfer of the topological information from the infrared to the THz domain mediated by nonlinear optical processes [2]. All these advances make it possible the emerging of spin-orbit photonic technologies, e.g. on-demand management of spatiotemporal couplings of light involving frequency-dependent orbital angular moment (OAM) content.

In LOMA, in collaboration with the Singular group (E. Brasselet), this internship will take place on the COSMat platform, especially dedicated to the development of novel broadband pulsed THz sources. Partly, the student will also interact with the CEA Tech in Pessac through their THz spectroscopy and imaging platform. The first objective is to extend the **development of THz vortex beams** in LOMA using the amplified femtosecond Ti:Sa laser source (800 nm, 1kHz, 2 mJ, 50 fs) of the platform COSMat. One possibility is to use an anti-resonant flexible hollow core THz waveguide to generate optical modes carrying OAM. The second and main objective concerns the **applications of THz vortex beams**. Our idea is to demonstrate, for the time in the THz spectral domain, the mechanical action of both SAM and OAM on a macroscopic object. Namely, a THz-absorbing object will be put into rotation once illuminated by a THz beam carrying SAM and/or OAM. In order to minimize mechanical losses associated with the motion of the object, the object will be trapped using an ultrasonic levitator. The student will have to develop the appropriated instrumentation to measure the droplet rotation (imaging, acquisition and analysis).

[1] A. Minasyan et al., Opt. Lett. **42**, 41 (2017).
[2] A. Al Dhaybi, JOSA B **36**(1), 12 (2019).