Master 2 Internship

Title: Active control of THz pulse generation from spintronic emitters for coherent THz time-resolved spectroscopy to detect magnetic ordering in real time

Type: experimental ~~and/or theoretical~~

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PhD funding (if any): none

Project:

There are numerous low-energy excitations (e.g., free carriers, phonons, magnons, Cooper pairs, etc.) in condensed matter lying in the terahertz (THz) spectral range (from 0.5 to 10 THz). Over the last two decades, ultrashort THz pulses have been used extensively, first to probe these excitations, then to directly excite and control them with the advent of more and more efficient sources in terms of intensity and duration [1].

Recently, nanometer-thick heterostructures built with ferromagnetic (FM) metal and nonmagnetic metal (NM) with strong spin-orbit coupling have shown their ability to generate, thanks to the inverse spin Hall effect, broadband and intense THz pulses [2]. Moreover, both the polarization and the intensity of the generated THz pulses can be tuned by adjusting the direction of the external magnetic field applied to the heterostructure [3]. Thus, these spintronic THz emitters open up new avenue in terms of THz pulses with controllable spatial and temporal shapes especially designed for the study and control of condensed matter.

The goal of this internship is to develop a new field of active control of THz pulse generation from spintronic emitters for coherent THz time-resolved spectroscopy. THz pulses with controllable spatial and temporal shapes will be generated. We will explore the possibility to generate on demand spatially Gaussian or Laguerre Gauss beams with given phase or/and amplitude distribution, or vortex beams with arbitrary orbital angular momentum. In addition to this spatial shaping, we will also add the possibility to control the spectral shape of the generated THz pulses by superposing THz pulses from several spintronic emitters. As an application, we will use these THz vortex beams to study the possibility of evaluating the temporal and spatial magnetic order within the magnetic layer of a FM/NM heterostructure. This work will be done in close collaboration with the team of S. Kumar at the Indian Institute of Technology Delhi.

References:

1. T. Kampfrath et al., Nature Photonics 7, 680 (2013).
2. T. Seifert, et al., Nature Photonics 10, 483 (2016).

Niwa et al., Optics Express 29, 13331 (2021).