Ultrafast liquid crystal dynamics: a close look to coupled electron-nuclear dynamics in a tunable order/disorder medium

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Although matter is divided into three well-defined phases, solid, liquid, and gas, there are certain states not exclusively belonging to either one of these categories. Liquid crystals (LCs) are one of these meso-phases, ordered like solids but fluid like liquids.

Despite the tremendous developments in LC-based technology and their ubiquitous relevance in our everyday life, dynamics in LCs have been well explored only down to nanosecond time scales, or GHz frequencies. Beyond this scale little is known, where eventually all the ultrafast molecular (picosecond) and electron (femtosecond) dynamics happen.

In this talk I will present the results we obtained along our journey to understand molecular and electron dynamics in representative thermotropic LCs.
In particular we demonstrated for the first time the possibility of performing high harmonic generation from mid infrared radiation. The harmonics emission turns out to be highly sensitive to the molecular organization within the specific mesophase when modifying the polarization direction of the driving field with respect to the local molecular alignment, as well as its degree of helicity.
In parallel, we investigated experimentally and (via collaborations) computationally the absorption from 1 to 8 THz as a function of temperature, resulting in a rich profile of vibrational modes. We were able to assign the modes either to intra-molecular (> 3THz) or inter-molecular origin (<3 THz). Looking at time- resolved responses, at the shortest time scale THz-induced modification in birefringence reveals an interesting interplay of electronic and nuclear responses on sub-ps time scales.

The fundamental understanding and consequent control of the electron and nuclear dynamics in LCs will demonstrate a completely new approach to exploit coherences in disordered media, ultimately targeting the light-induced emergence of new electronic properties.