SFB 1277 Seminar

Speaker: Niloufar Nilforoushan
Laboratoire de Physique de l'École Normale Supérieure, Paris

Date: Wednesday, March 9th, 2022, 10:00 am, via Zoom
Zoom Link
Meeting ID: 635 1781 1339
Passcode: 904448

Topic: Out-of-equilibrium electron dynamics of quantum materials

Abstract:
Quantum materials (i.e. strongly correlated systems and topological materials) show emergent phenomena that appear by intricate interactions among different electrons attributes, such as charge, spin, orbital, and topology. Ultrafast spectroscopic techniques provide deep insights into these interactions by selectively exciting them and tracking the subsequent decay pathways back to the ground states. In some materials, the ultrafast dynamics might also unveil and stabilize hidden phases inaccessible by thermal pathways.
We show that the prototype strongly correlated material V_2O_3 presents a transient non-thermal phase developing immediately after ultrafast photoexcitation and lasting a few picoseconds. By combining different ultrafast techniques and theoretical calculations, we prove that the non-thermal phase is triggered by a selective electron-lattice interplay [1].
Next, we present the correlated Dirac material $BaCo_{1-x}Ni_xS_2$. We show that not only does the doping x move and reshape Dirac nodal lines in *k*-space, but it also controls the metal-insulator transition by affecting the electron correlations [2]. We also give evidence of a remarkable photoinduced reduction of the Fermi velocity of these Dirac bands. Theoretical calculations explain the band renormalization by a reduction of the electron interaction range upon photoexcitation in layered Dirac materials [3].
In the above-mentioned systems, the out-of-equilibrium states are triggered by photon energies (~1.55 eV) that only act on electrons, impose limitations on selectivity of electronic excitations, and are much higher than energy scales of low-lying excitations and lattice vibrational modes in quantum materials. Therefore, a frequency tunable source giving access to intense mid-infrared and terahertz (THz) pulses is particularly appealing in understanding and manipulating light induced states. We demonstrate a table-top source delivering milliwatt-level ultra-broadband THz pulses with electric fields exceeding 100 kV/cm at a repetition rate of 200 kHz [4]. Our source opens a route towards nonlinear and time-resolved THz experiments with high signal-to-noise ratios.

[1] G. Lantz *et al.*, Ultrafast evolution and transient phases of a prototype out-of-equilibrium Mott–Hubbard material, Nat. Commun. **8,** 13917 (2017).
[2] N. Nilforoushan *et al.*, Moving Dirac nodes by chemical substitution, PNAS. **118,** e2108617118 (2021).
[3] N. Nilforoushan *et al.*, Photoinduced renormalization and electronic screening of quasi-two-dimensional Dirac states in $BaNiS_2$, Phys. Rev. Research **2**, 043397 (2020).
[4] N. Nilforoushan *et al.*, Ultra-broadband THz pulses with electric field amplitude exceeding 100 kV/cm at a 200 kHz repetition rate, submitted.

Host: Prof. Dr. Rupert Huber