Femtosecond Terahertz Studies of Excitonic Correlations and Photo-induced Phase Transitions in Semiconductors and VO_2

Rupert Huber, Department of Physics, University of Konstanz, Universitätsstraße 10, 78464 Konstanz, Germany

In condensed matter systems, many-body correlations of charged particles often give rise to resonances in the meV-range, such as phonons, plasmons, internal excitonic transitions, or correlation induced energy gaps. These low-energy modes govern important macroscopic material properties. Ultrabroadband terahertz (THz) technology has been advanced in recent years to directly trace such resonances, on a femtosecond time scale.
I will summarize the advantages of field-resolved THz spectroscopy and present our recent THz studies of excitons, Coulomb-bound pairs of one electron and one hole, in semiconductors. We observe novel fundamental phenomena such as stimulated emission of electromagnetic radiation from atom-like internal excitonic transitions [1] and renormalization of the intra-excitonic fine structure in the high-density limit approaching the Mott insulator-metal transition [2]. In the second part, I will report latest investigations of coherent structural dynamics and electronic correlations during an ultrafast insulator-to-metal phase transition in vanadium dioxide (VO_2), triggered by a 12-fs light pulse [3]. The results shed new light on the driving force behind this phase transition and point out promising perspectives for future studies of strongly correlated electron systems.

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