UNIVERSITÄT LEIPZIG

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Physics Colloquium

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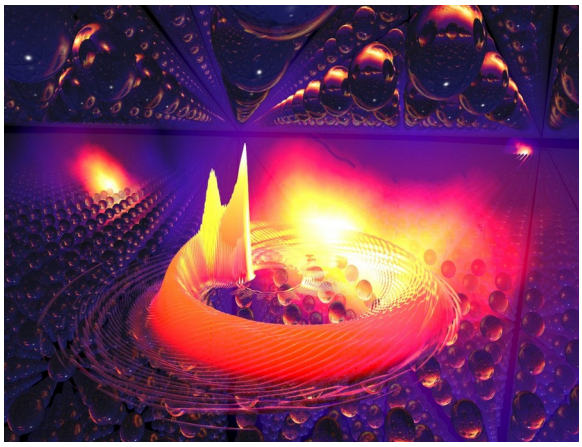
Terahertz strong-quantum control of solid state excitations with subcycle and subwavelenth precision

Terahertz (THz) spectroscopy has opened up exciting new chapters in ultrafast condensed-matter physics. Phase-locked, single-cycle THz waveforms are uniquely suited to control the quantum motion of electrons and spins, while the resulting field dynamics can be traced on subcycle time scales. Here, we review some of the recent developments in THz solid-state strong-field nonlinear spectroscopy.



We discuss how lightwave acceleration of charges by atomically strong multi-THz pulses leads to all-coherent charge transport throughout the entire Brillouin zone of bulk solids, including dynamical Bloch oscillations. Even more spectacularly, Dirac fermions of topological surface states of Bi_2Te_3 support inertia-free, ballistic subcycle currents with coherent electron transport across distances that largely exceed even typical gate widths of transistors, moving lightwave-electronic devices into practical reach. We complement this subcycle temporal resolution by subwavelength control of electromagnetic fields in custom-cut metallic microresonator structures. Here, light-matter interaction can be tailored on length scales far below the far-field diffraction limit. This powerful concept has enabled minimally dissipative, ballistic spin switching in antiferromagnets, carrier-wave Rabi flopping, or high-order nonlinearities of electronic excitations. Ultimately, in THz cavity quantum electrodynamics, light-matter coupled structures explore a novel limit where the vacuum Rabi frequency – the rate of spontaneous emission and reabsorption of photons – exceeds even the carrier frequency of light itself.

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