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Track and Control Charge and Spin dynamics at Ultrafast Timescales

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In electronics, functionality is achieved through switching between electronic states of matter by applying external electric or magnetic fields. Strong couplings in-between charge carriers and to the crystal lattice conspire to randomize energies and momenta of the carriers extremely fast and efficiently, leaving little room for subsequent coherent manipulation.

However, the prospects of coherent control protocols as demonstrated in isolated atomic systems are alluring and contemporary ultrafast laser sources might be a new ingredient to overcome this entrapment. This talk will discuss two experiments demonstrating that single cycle optical fields at optical frequencies allow manipulating electronic and spin degrees of freedom in solid state systems at optical clock rates, possibly faster than de-coherence.

Ultrafast bidirectional energy transfer between a light-field and the band-structure of silica proves the early times reversibility of electronic excitations and holds promise of novel ultrafast, coherent optoelectronic applications[1].

As a corollary of this ultrafast coherent modification of the electronic system, in suitably chosen heterostructures also the spin system can be manipulated coherently. Optically induced spin transfer is demonstrated as a route to the direct, all-optical manipulation of macroscopic magnetic moments on previously inaccessible attosecond timescales[2].

[1] A. Sommer, Nature. 534, 86–90 (2016)
[2] F. Siegrist, Nature. 571, 240–244 (2019)