Coherent trajectories through phase transitions in complex systems: topological defect dynamics and hidden states

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Multipulse methods in femtosecond spectroscopy can be used to study the coherent evolution of the order parameter through single particle and collective excitations. In addition they can be used to study topological defects created in symmetry breaking transitions. Two types of systems are of interest in such studies: superconductors and charge-density wave (CDW) systems displaying symmetry-breaking transitions (SBT).

In CDW systems, the observation of the collective amplitude mode in real time allows us to follow the coherent oscillations of the order parameter through an SBT. During the transition, as a result of spatial inhomogeneity, topological defects are coherently created, whose annihilation can lead to observable distortions of the collective mode dynamics.

Remarkably, the experimental technique also allows us to investigate transitions to new hidden states of matter, which can only be reached under non-equilibrium conditions. We present data on a new stable hidden state of 1T-TaS_2[2], demonstrating bistable switching to and from the hidden state with ultrashort laser pulses, switching the system from a Mott insulator to a metal. The switching is accompanied by a resistance change of 3 orders of magnitude, a change of the dielectric constant and remarkable magnetoresistance switching. The hidden state is shown to be topologically protected, which explains its remarkable stability.

Finally, in superconductors, topological defects created during a freely evolving transition may be detectable via the QP response due to the depression of the order parameter as a result of vortex creation[3].

1. R.Yusupov et al., Nat.Phys. 6, 681 (2010).
2. L. Stojchevska et al., unpub. 2013.
3. P.Kusar et al., arXiv:1207.2879