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Ultrafast Optical Control of Complex Quantum Materials

It is well known fact that various phase transitions in condensed matter can by triggered by external parameters such as temperature, pressure, electric field or magnetic field. Finding systems that show phase transitions triggered by external stimulation of light became a particular interesting field of research.
Advanced nonlinear optical methods such as ultra-broad band pump-probe spectroscopy open new ways of controlling ultrafast dynamics in complex solid-state materials on unprecedented timescales. In quantum materials, finding new ways of manipulating the complex interplay of electronic phases or effectively tuning electronic interactions opens new avenues in controlling physical properties and designing new functionalities.
I will show how we investigate different scenarios like the balancing between competing phases triggered by ultrashort light pulses or possibilities of dynamical stabilization of new states of matter in periodically driven light fields. In particular I will discuss the remarkable possibilities to induce superconductivity in high temperature cuprate superconductors by melting competing “stripe”-order [1] or even promoting it to temperatures far above Tc; for some underdoped materials even up to room temperature for a few picoseconds [2,3]. Possible light-induced superconductivity in the doped fullerides K_3C_{60} [4] will serve as important example that inducing such intriguing effects is a more general effect and not restricted to the rather specialized class of cuprate systems.

[1] D. Fausti et al. Science **331**, 189 (2011).
[2] S. Kaiser et al. Phys. Rev. B **89**, 184515 (2014).
[3] W. Hu et al. Nature Materials **13**, 705 (2014).
[4] M. Mitrano et al. Nature **530**, 461 (2016).