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Title: Experimental Approaches to the non-equilibrium physics of complex quantum materials

Abstract: The rich phase diagrams of many transition metal oxides (TMOs) is the result of the intricate interplay between electrons, phonons, and magnons. This makes TMOs very susceptible to external parameters such as pressure, doping, magnetic field, and temperature which in turn can be used to finely tune their properties. The same susceptibility makes TMOs the ideal playground to design experiments where the interaction between tailored electromagnetic fields and matter can trigger the formation of new, sometimes exotic, physical properties. This aspect has been explored in time domain studies and has led to the demonstration that ultrashort mid-IR light pulses can “force” the formation of quantum coherent states in matter, disclosing a new regime of physics where thermodynamic limits may be bridged and quantum effects can, in principle, appear at ambient temperatures.

In this presentation, I will review the bases of experimental approaches to non equilibrium spectroscopies of complex quantum materials and demonstrate the feasibility of a light-based control of quantum phases in real materials [2,3,4]. I will introduce our new approaches to time domain spectroscopy going beyond mean photon number observables [5-11] and I will elaborate on our current directions on leveraging both driving and confinement to control the onset of quantum coherent states in complex materials[12,13].

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