TT 44: Focus Session: Non-Equilibrium Dynamics in Light-Driven Materials: Theory Meets Experiment (joint session O, TT, organized by O)

Time: Wednesday 10:30–13:00 Location: TRE Phy

Invited Talk TT 44.1 Wed 10:30 TRE Phy

Electronic orders in light-driven materials — •Philipp Werner[1], Yuta Murakami[1], Hugo Strand[1], Shintaro Hoshino[2], and Martin Eckstein[3] — [1]Department of Physics, University of Fribourg, 1700 Fribourg, Switzerland — [2]RIKEN Center for Emergent Matter Science, Wako, 351-0198 Saitama, Japan — [3]Max Planck Research Department for Structural Dynamics, University of Hamburg-CFEL, 22761 Hamburg, Germany

The prospect of nonequilibrium control of material properties has caught the interest of the condensed matter community. In particular, recent experiments demonstrating a light-enhanced superconducting-like state in cuprates and fulleride compounds has triggered a number of theoretical studies on order parameter dynamics in lattice systems perturbed by periodic driving or strong quasi-static fields.

Here, we use the nonequilibrium dynamical mean field theory in a Kadanoff-Baym and Floquet implementation to address some relevant issues which have been ignored in previous studies. In particular, we will consider parametric phonon driving in the Holstein model, and show that the nonthermal energy distribution in the driven state generically leads to a weakening of the superconducting order.

As a second example, we will discuss order parameter switching by quasi-static electric fields in fulleride compounds. Here, we will focus on the Jahn-Teller metal phase, which has recently been identified as an orbital-selective Mott state. Electric field pulses can switch this composite ordered state between physically distinct realizations, which may be potentially exploited in ultrafast persistent memory devices.

Invited Talk TT 44.2 Wed 11:00 TRE Phy

Pump/probe photoemission spectroscopy in charge density wave insulators — •James Freericks — Department of Physics, Georgetown University, Washington, DC 20057

In this talk, I will discuss time-resolved photoemission spectroscopy in charge-density-wave (CDW) insulators that form due to an electronic nesting instability. A strongly correlated electronic CDW has a number of interesting features. As the temperature is raised, the gap in the spectrum remains unchanged all the way up to Tc, while the gap fills with subgap states, which eventually metallize the system. There is a critical interaction strength where the metallization occurs the instant the temperature is increased from 0. The system also displays Mott-like physics at strong interaction strength. We illustrate that these systems have an interesting response to the pump. In some cases, the gap region fills in due to the pump, implying the disappearance of the spectral gap, but in the presence of a well formed spatial charge-density-wave order parameter. At the critical interaction strength, the system is exceedingly difficult to pump. Whatever energy is pumped in on the leading edge of the electric field, is pumped out on the trailing edge. These calculations result from the exact solution of the nonequilibrium Falicov-Kimball model via dynamical mean-field theory. We also discuss experimental implications for these results.

Invited Talk TT 44.3 Wed 11:30 TRE Phy

Controlling magnetism and pairing in a periodically driven Hubbard model — •Stephen Clark[1,2], Jonathan Coulthard[3], Juan Jose Mendoza-Arenas[4], Martin Eckstein[2], Dieter Jaksch[3], and Andrea Cavalleri[2,3] — [1]Department of Physics, University of Bath, UK — [2]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — [3]Department of Physics, University of Oxford, UK — [4]Departamento de Fisica, Universidad de los Andes, Colombia

In this talk I will describe theory work illustrating striking effects of periodic driving for three different regimes: (i) high frequency $\omega \gg U, t$, (ii) resonant $\omega = nU$ and (iii) in-gap $U \gg \omega \gg t$. Floquet theory when $U \gg t$ predicts renormalisation of t for (i), substantial modifications of both t and U for (ii) and a suppression of t with super-exchange J essentially unchanged for (iii). To demonstrate this physics I will outline non-equilibrium DMFT results showing how the mechanism governing the magnetic melting of an initial classical Neel state can be controlled and switched in the half-filled Hubbard model in infinite dimensions. I will also describe how attaining dominant super-exchange interactions in regime (iii) leads to the emergence of strong singlet-pairing correlations in the driven state. This is demonstrated in the one-dimensional Hubbard model below half-filling in the thermodynamic limit using time-dependent DMRG calculations. By spanning different fillings, dimensions and driving regimes these results show how periodic driving leads to compelling new pathways for controlling magnetism and potentially engineering light-induced superconductivity.

Invited Talk TT 44.4 Wed 12:00 TRE Phy

Ultrafast Terahertz and XUV ARPES Probes of Quantum Materials Dynamics — •Robert A. Kaindl — Materials Sciences Division, E. O. Lawrence Berkeley National Laboratory, Berkeley, USA

In this talk I will discuss the application of ultrashort light pulses - from THz to Extreme-UV - to the study of vibrational coupling and emergent correlations in quantum materials. Transition-metal oxides, in particular, exhibit an intriguing self-organization of charges into nanoscale "stripes", whose driving forces and role in high-Tc superconductivity remain unresolved. We will first present transient multi-THz and mid-IR experiments that capture the initial steps of vibrational symmetry breaking and charge ordering in stripe-phase nickelates, indicating the precursor role of charge localization and exposing the electronic and structural coupling dynamics [1]. In the second part, I will discuss our development of ultrafast angle-resolved photoemission spectroscopy (ARPES) with extreme-ultraviolet (XUV) pulses at 50-kHz repetition rate, and its application to sensitively access electronic dynamics of quantum materials across momentum space [2]. Studies of semiconducting and correlated dichalcogenides access the crossover of light-induced perturbation and melting of charge density waves and provide evidence for excitonic signatures in ARPES spectra. [1] G. Coslovich, et al. Nature Comm. 4, 2643 (2013); arXiv:1603.07819 (2016). [2] H. Wang, et al. Nature Comm. 6, 7459 (2015); J. H. Buss, et al. in preparation (2016).

Invited Talk TT 44.5 Wed 12:30 TRE Phy

Ultrafast spin interactions revealed with terahertz radiation — •Tobias Kampfrath — Fritz Haber Institute of the Max Planck Society, Berlin, Germany

The terahertz (THz) frequency range is attracting increasing interest for both applied and fundamental reasons. First, bit rates in current information technology may soon approach the THz range. Second, its low photon energy (4.1 meV at 1 THz) makes THz radiation an excellent probe and stimulus of many fundamental excitations of solids, for instance phonons and Cooper pairs. This talk considers experiments showing that THz pulses are also a very useful and versatile tool to reveal spin interactions on the time scales of elementary relaxation processes. Examples include (i) the ultrafast transfer of energy and angular momentum between phonons and the ordered electron spins of the textbook ferrimagnet yttrium iron garnet (YIG) as well as (ii) the femtosecond transport of magnons across the interface of the spin Seebeck bilayer system YIG/Pt.