DY 55: Focus: Emergent phenomena in driven quantum many-body systems (joint session DY/TT)

In the past years, driven quantum many-body systems have been demonstrated to offer a huge playground for emergent states of matter. These range from light-induced switching of phases in solids and laser-modified chemical reactions via Floquet topological states in photonic crystals to artificial gauge fields in optical lattices and Floquet time crystals in many-body localized systems. The goal of the proposed session Emergent phenomena in driven quantum many-body systems is to bring together distinguished scientists from a variety of fields who work on driven quantum systems from different perspectives, both theoretically and experimentally, to stimulate interdisciplinary discussions and guide future research directions. For the general audience, this is an opportunity to gain a broad overview of a growing research field with great potential and many open questions.

Coordinator: France Manghi (Modena)

Time: Thursday 9:30–11:30 Location: EB 107

Invited Talk DY 55.1 Thu 9:30 EB 107
Nuclear and electronic dynamics in ultrafast photoinduced charge separation — •Carlo Andrea Rozzi — CNR-NANO, Modena, Italy

The sub-ps dynamics of photoinduced charge separation is studied in several prototypical photovoltaic materials by combining TDDFT and molecular dynamics simulations. The results are validated against high time resolution pump-probe spectroscopy, and ultrafast electron diffraction. The role of coherent coupling between electronic and nuclear degrees of freedom is shown to be of key importance in triggering charge delocalization and transfer both in covalently bonded molecules[1] and non-bonded bulk heterojunctions[2]. The possible exploitation of our findings in order to design and synthesize novel molecular scaffolds[3] for photovoltaic applications is discussed. Further work in progress on ultrafast photoexcitation of polymer-copolymer aggregates and perovskites is presented.

[1] C. A. Rozzi et al., Nat. Comm 4, 1602 (2013) [2] S. Falke et al., Science 344, 1001 (2014) [3] S. Pittalis et al., Adv. Func. Mat. 25, 2047 (2015) [4] G. M. Vanacore et al., arXiv:1801.03731

Invited Talk DY 55.2 Thu 10:00 EB 107
Theory of pump-probe spectroscopy: Ultrafast laser engineering of ordered phases and microscopic couplings — •Michael Sentef — Max Planck Institut für Struktur und Dynamik der Materie (CFEL), Hamburg

Intense femtosecond laser pulses, spanning a large range of photon energies from the X-ray to the THz regime, allow for controlled excitations ("pump") and monitoring ("probe") of the nonequilibrium dynamics of all the relevant microscopic degrees of freedom in solids. The field of ultrafast materials science is currently evolving towards ultrafast laser engineering of nonthermal phases of matter with novel properties. I will discuss recent theoretical progress in understanding these diverse phenomena from microscopic models and nonequilibrium simulations. I will show examples of light-enhanced superconductivity in an electron-phonon system from classical nonlinear phononics [1] and laser-controlled order competition between superconductivity and charge-density waves [2]. I will discuss laser engineering of microscopic couplings in graphene [3] based on quantum nonlinear phononics [4]. Finally, I will show ab initio time-dependent density functional theory results for laser-engineered Hubbard U in NiO [5].

[1] M. A. Sentef et al., Phys. Rev. B 93, 144506 (2016). [2] M. A. Sentef et al., Phys. Rev. Lett. 118, 087002 (2017). [3] E. Pomarico et al., Phys. Rev. B 95, 024304 (2017). [4] M. A. Sentef, Phys. Rev. B 95, 205111 (2017). [5] N. Tancogne-Déjean et al., arXiv:1712.01067.

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DY 55.3 Thu 10:30 EB 107
Transient dynamics in an excitonic insulator: Fast computation of nonequilibrium Green's functions — •Riku Tuovinen[1], Denis Golež[2], Michael Schüler[2], Martin Eckstein[3], and Michael Sentef[1] — [1]Max Planck Institute for the Structure and Dynamics of Matter, 22761 Hamburg, Germany — [2]Department of Physics, University of Fribourg, 1700 Fribourg, Switzerland — [3]Department of Physics, University of Erlangen-Nürnberg, 91058 Erlangen, Germany

A standard approach to nonequilibrium many-body problems is the Keldysh Green's function technique [1]. Information about the studied system, e.g. photoemission spectra etc., is encoded into the Green's function. To access this, we have to consider coupled integro-differential equations (Kadanoff-Baym equations), whose efficient solution is not trivial [2]. The Generalized Kadanoff-Baym Ansatz (GKBA) offers a simplification by decomposing the two-time-propagation of the Green's function into the time-propagation of a time-local density matrix [3]. We discuss the time-propagation method à la GKBA and present some benchmark simulations against the full solution of the Kadanoff-Baym equations, concentrating on a simple model for an excitonic insulator [4]. We investigate the dynamics of competing orders and how the balance between them could be controlled by laser driving.

[1] G. Stefanucci and R. van Leeuwen, Nonequilibrium many-body theory of quantum systems, CUP (2013) [2] A. Stan et al., J. Chem. Phys. 130, 224101 (2009) [3] P. Lipavský et al., Phys. Rev. B 34, 6933 (1986) [4] D. Golež et al., Phys. Rev. B 94, 035121 (2016)

DY 55.4 Thu 10:45 EB 107
Entanglement growth and thermalisation after a spatially inhomogeneous quench — Maximilian Schulz[1,2], •Chris Hooley[1], Roderich Moessner[2], and Frank Pollmann[3] — [1]SUPA, University of St Andrews, UK — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [3]Technische Universität München, Germany

We consider a system of spinless fermions in a strong optical lattice plus a harmonic trap and uncorrelated disorder. We subject them to a quantum quench that consists of an instantaneous displacement of the trap centre.

In [1] we presented an analysis of the behaviour of the non-interacting version of the problem. We observe that (a) even weak disorder strongly breaks the parity symmetry of the clean problem, qualitatively changing the nature of the infinite-time steady state, and (b) the approach to this long-time state is extremely slow, since it involves the fermions' tunnelling across a broad 'Bragg-forbidden' region.

Here we show that the ingredients in the above study also present a way to realise slow logarithmic entanglement growth as usually observed in many-body localized systems without disorder and even without interactions. We present evidence for this by a time-evolving block decimation and exact diagonalization analysis of the interacting and non-interacting cases.

[1] M. Schulz, C.A. Hooley, and R. Moessner, Phys. Rev. A. 94, 063643 (2016).

DY 55.5 Thu 11:00 EB 107
Creating a superfluid by kinetically driving a Mott insulator — Gregor Pieplow, Fernando Sols, and •Charles Creffield — Universidad Complutense, Madrid, Spain

We study the effect of time-periodically varying the hopping amplitude (which we term "kinetic driving") in a one-dimensional Bose-Hubbard model, such that its time-averaged value is zero. By using Floquet analysis, we derive a static effective Hamiltonian in which nearest-neighbor single-particle hopping processes are suppressed, but all even higher-order processes are allowed. Unusual many-body features arise from the combined effect of non-local interactions and correlated tunneling. At a critical value of the driving, the system passes from a

Mott insulator to a superfluid formed by two quasi-condensates with opposite nonzero momenta. A many-body cat state combining the two macroscopically occupied momentum eigenstates emerges even with hard-wall boundary conditions. This work shows how driving of the hopping energy provides a novel form of Floquet engineering, which enables atypical Hamiltonians and exotic states of matter to be produced and controlled.

DY 55.6 Thu 11:15 EB 107

Time evolution, dynamics and control of edge states in laser-driven graphene nanoribbons — •Matteo Puviani[1] and Andrea Bertoni[2] — [1]Università degli Studi di Modena e Raggio Emilia, Modena, Italy — [2]CNR Institute of NanoSciences - S3, Modena, Italy

An intense laser field in the high-frequency regime drives carriers in graphene nanoribbons out of equilibrium and creates topologically-protected edge states. Based on a solution of the Floquet Hamiltonian we have studied these states in different regimes of intensity and polarization. We show that the time-dependent band structure contains many unconventional features that are not captured by considering the Floquet eigenvalues alone. By analyzing the evolution in time of the state population we have identified regimes for the emergence of time-dependent edge states responsible of charge oscillations across the ribbon. Furthermore, we show that they exhibit a robust dynamics also in the presence of very localized lattice defects, which is characteristic of topologically non-trivial behaviour. We eventually reveal how it is possible to control them applying an electrostatic potential barrier or creating a Quantum Point Contact, making them promising candidates for flying qubits architectures.