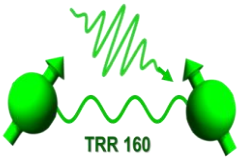


Discussion Workshop SFB 1242/TRR 160

Non-equilibrium dynamics of condensed matter in the time domain: A discussion workshop on recent developments in theory

University of Duisburg Essen, Faculty of Physics
Campus Duisburg, Room MG 465

Wednesday – November 13th, 2019

08:45 a.m. **Welcome and Opening**
U. Bovensiepen, University of Duisburg-Essen

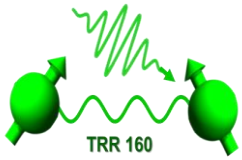
09:00 a.m. J. Freericks, Georgetown University, Washington
Ultrafast Thermometry in Pump-Probe Experiments
We discuss the issues surrounding how one can perform ultrafast thermometry. We propose two different possibilities: (i) measurement of photoemission spectra and electronic Raman scattering to determine when a system thermalizes and (ii) core-hole XPS or XAS as a sensitive probe to the energy content of excited electrons.

09:50 a.m. F. Queisser, TU Dresden
Boltzmann Relaxation Dynamics in the Strongly Interacting Fermi-Hubbard Model
Via the hierarchy of correlations, we study the Mott insulator phase of the Fermi-Hubbard model in the limit of strong interactions and derive a quantum Boltzmann equation describing its relaxation dynamics. In stark contrast to the weakly interacting case, we find that the scattering cross sections strongly depend on the momenta of the colliding quasi-particles and holes. Therefore, the relaxation towards equilibrium crucially depends on the spectrum of excitations. For example, for particle-hole excitations directly at the minimum of the (direct) Mott gap, the scattering cross sections vanish such that these excitations can have a very long life-time.

10:40 a.m. Coffee Break

11:10 a.m. P. Bleicker, TU Dortmund
On the Evolution of Fermionic Systems after Interaction Quenches
Understanding highly excited systems in non-equilibrium states imposes high requirements on theoretical techniques since a variety of commonly used methods fail once the equilibrium is left. We resort to approximate methods such as the iterated Heisenberg equations of motion and to exact methods such as exact diagonalization or the Chebyshev expansion technique to gain insight into the dynamics of the Fermi-Hubbard model after a global interaction quench. We present results for the one-dimensional model for which we are able to identify a crossover instead of a sharp dynamical transition depending on the strength of the quench. We developed ways to capture the infinite-time behaviour of observables by an analytical approach based on stationary phases. Currently, we extend these studies to arbitrarily shaped finite-size site clusters and examine thermalization and the degree of fluctuations in integrable and non-integrable models.

11:40 a.m. S. Manmana, Georg-August-University Gottingen
Detecting Superconductivity Out-of-Equilibrium
Recent experiments pose the question for how to reliably identify the emergence of long-range order, in particular superconductivity, in non-equilibrium experiments. By studying a quantum quench in an extended Hubbard model, we find that it does not suffice to study the time evolution of the optical conductivity to identify non-equilibrium superconductivity in transient states. We find indications for the formation of a condensate in the two-particle channel of proposed time-resolved ARPES-type experiments.



Discussion Workshop SFB 1242/TRR 160

Non-equilibrium dynamics of condensed matter in the time domain: A discussion workshop on recent developments in theory

University of Duisburg Essen, Faculty of Physics
Campus Duisburg, Room MG 465

Wednesday – November 13th, 2019 – Continuation

12:30 p.m. Lunch

02:00 p.m. D. Manske, Max Planck Institute for Solid State Research
Higgs Spectroscopy of Superconductors
During the last years we have developed a classification scheme that allows to characterize Higgs oscillations of all possible symmetries in non-equilibrium. Using polarized light in different directions, we predict that it is possible to map out the underlying gap symmetry of the superconducting ground state. Applying our theory of Higgs spectroscopy to THz tr-ARPES experiments would open a unique approach to distinguish between different symmetries of the superconducting condensate, even for new and unknown superconductors.

02:50 p.m. B. Sothmann, University of Duisburg-Essen
Order Parameter Dynamics in Time-Dependently Driven Superconductor-Quantum Dot Hybrids
Superconductors driven out of equilibrium by an applied temperature bias give rise to interesting transport phenomena such as phase-dependent thermoelectric charge and heat currents. Here, we discuss the dynamics of the proximity-induced order parameter of the quantum dot when the system is subject to an additional time-dependent phase bias.

03:40 p.m. Coffee Break

04:10 p.m. R. Pentcheva, University of Duisburg-Essen
Electronic Excitations in Complex Oxide Materials
This talk will address the role of many body effects beyond standard density functional theory to describe the optical and x-ray absorption spectra of prominent oxides such as SrTiO3 [1]and MgO. For both systems taking into account quasiparticle (GW) and in particular excitonic effects (Bethe-Salpeter equation) is decisive to obtain good agreement with experiment. Moreover, the electronic reconstruction of the double perovskite Sr2CoIrO6 w.r.t. the end members SrIrO3 and SrCoO3 and the effect of strain will be discussed. [1] V. Begum, M. E. Gruner and R. Pentcheva, Phys. Rev. Materials 3, 065004 (2019).

05:00 p.m. J. Kroha, University of Bonn
Time-domain THz spectroscopy for heavy-fermion materials
Time-resolved terahertz spectroscopy has recently been introduced as a novel tool to investigate the quasiparticle dynamics in heavy-fermion systems, in particular, their breakdown near a magnetic quantum phase transition in these systems. We review recent experiments on CeCu(6-x)Au(x) and on YbRh2Si2 as well as the theory to explain the experiments and consequences for quantum critical scenarios.

06:00 p.m. Dinner

Discussion Workshop SFB 1242/TRR 160

Non-equilibrium dynamics of condensed matter in the time domain:
A discussion workshop on recent developments in theory

University of Duisburg Essen, Faculty of Physics
Campus Duisburg, Room MG 465

Thursday – November 14th, 2019

09:00 a.m. I. Eremin, Ruhr-University Bochum
Collective Modes Out-of-Equilibrium in Unconventional Superconductors with Competing Ground States
Motivated by the recent development of terahertz pump-probe experiments, we investigate the short-time dynamics in superconductors with multiple attractive and competing pairing channels. Our work shows the potential of modern ultrafast experiments to address the collective excitations in unconventional superconductors and highlights the importance of sub-dominant interactions for the non-equilibrium dynamics in these systems.

09:50 a.m. M. Sentef, Max Planck Institute for the Structure and Dynamics of Matter
Engineering Correlations and Topology in Quantum Materials with Classical and Quantum Light
The use of classical light to probe and manipulate electronic properties of quantum materials is a common theme in ultrafast materials science. Here I will discuss what can be gained by going from the purely classical-light regime towards the quantum limit, achieved for instance in Bragg-reflecting cavities or on metal surfaces (nanoplasmonics). I will show proof-of-principle studies including light-modified magnetic exchange couplings, superconductivity, and topology.

10:40 a.m. Coffee Break

11:10 a.m. F. Anders, TU Dortmund
Restoring the Continuum Limit in Simulation of the Non-Equilibrium Dynamics by Finite Systems
Derivations are expected between the true steady-state of a continuum model and the predictions by a simulation using a finite size representation. We propose a novel hybrid method by combining the time-dependent numerical renormalization group approach addressing the non-equilibrium dynamics on a discretized Wilson chain with a Bloch-Redfield approach that includes the hierarchy of additional reservoir analytically derived from the original continuum. We present the spin and charge quenches in simple quantum impurity models and prove analytically that these systems eventually thermalize.

12:00 p.m. D. Schulze, Martin-Luther University of Halle-Wittenberg
High-Harmonic Generation in Layered Systems Driven by Intense Laser Pulses
We consider the quantum dynamics of multilayered systems based on graphene and transition metal dichalcogenides driven by intense laser fields. The goal is twofold: 1) We seek a local source for short, high frequency radiation pulses. 2) Analyzing the emitted, time-dependent spectra we trace the footprints of intrinsic spin-dependent mechanisms and topology effects.

12:30 p.m. Lunch

Discussion Workshop SFB 1242/TRR 160

Non-equilibrium dynamics of condensed matter in the time domain: A discussion workshop on recent developments in theory

University of Duisburg Essen, Faculty of Physics
Campus Duisburg, Room MG 465

Thursday – November 14th, 2019 – Continuation

02:00 p.m. G. Fabiani, Radboud University
Quantum Magnonics at the Edge of Space and Time
We study the ultrafast dynamics of nonlocal quantum spin correlations in the two-dimensional Heisenberg antiferromagnet triggered by ultrashort perturbations of exchange interactions. Surprisingly, although the dominant spin correlation oscillations are between nearest neighbors, which would correspond to magnons with nearly zero group velocity, we find spreading of correlations at the highest possible magnon speed.

02:50 p.m. G. Uhrig, TU Dortmund
Non-Equilibrium Stationary States in Driven Quantum Magnets
Motivated by quantum dots subjected to periodic laser pulses, we discuss how and why in periodically driven central spin models the entropy can be reduced substantially. This may serve a protocol to prepare coherent quantum states. Additionally, we study spin chains driven by light via appropriate optical phonons. The key issue is to prepare non-equilibrium stationary states and to study their properties.

03:40 p.m. Coffee Break

04:10 p.m. D. Waltner, University of Duisburg-Essen
Periodically Excited Chain-Like Systems
We studied chain-like interacting many-particle systems in the non-equilibrium situation resulting from periodic excitations by short and strong magnetic field pulses. In my talk, I will give an overview of our results to describe the short-time dynamics of such systems for arbitrary chain length. In particular, we developed methods to reduce the large size of the Hilbert space dimension and to connect the dynamics in this system to the corresponding classical dynamics.

05:00 p.m. M. Gruner**,** University of Duisburg-Essen
Polarization Dependence of Optical Excitations in Metal Insulator Hererostructures
We discuss the layer-resolved dynamics of the electronic structure of a Fe/MgO(001) multilayer system after an optical excitation in the framework of real-time time-dependent density functional theory (RT-TDDFT). We compare short optical pulses with in-plane and out-of plane polarization directions of the light at a frequency smaller than the band gap of bulk MgO. Here, we observe strong anisotropy of the dynamic reponse of the system with the orientation of the electric field: substantial transient changes to the electronic structure, which persist after the duration of the pulse, are mainly observed for in-plane polarized electric fields, corresponding to a laser pulse arriving perpendicular to the interface. Moreover, a strong orbital dependence of the excitations is found with transfer from in plane to out-of-plane occupation.

06:00 p.m. Dinner

Discussion Workshop SFB 1242/TRR 160

Non-equilibrium dynamics of condensed matter in the time domain:
A discussion workshop on recent developments in theory

University of Duisburg Essen, Faculty of Physics
Campus Duisburg, Room MG 465

Friday – November 15th, 2019

09:00 a.m. P. Kratzer, University of Duisburg-Essen
Boltzmann Relaxation Dynamics of Strongly Interacting Spinless Fermions on a Lattice
Via the hierarchy of correlations, we study strongly interacting fermions on a lattice and derive a quantum Boltzmann equation describing their relaxation dynamics. Interestingly, in the strong-coupling limit, collisions between particles and holes dominate over particle-particle and hole-hole collisions - in stark contrast to weakly interacting systems. Therefore, the relaxation towards equilibrium strongly depends on what kinds of excitations (particles or holes or both) are present initially. Numerical solutions of the kinetic equation illustrate this finding.

09:50 a.m. J. König, University of Duisburg-Essen
Full Counting Statistics of Electron Tunneling in Coulomb-Blockade Devices: Generalized Factorial Cumulants
In this talk, we show how the full counting statistics (FCS) of electron tunneling in Coulomb-blockade device can be used to acquire information about the system that is inaccessible from measuring the average transferred charge only. In particular, we demonstrate how so-called generalized factorial cumulants can be used to reveal the presence of interaction, correlated electron tunneling in Andreev-reflection processes, violation of detailed balance, coherent spin precession, or an attractive electron-electron interaction. Finally, we present results of a recent experiment in which the analysis with the help of factorial cumulants gave access to the non-equilibrium dynamics of spin relaxation even in an equilibrium transport measurement.

10:40 a.m. Coffee Break

11:10 a.m. M. Eckstein, Friedrich-Alexander University of Erlangen-Nuremberg
Theory of photo-doped states in correlated materials
The transfer of electronic populations between states (photo-doping) is potentially the most straightforward path towards photo-induced phase transitions - if it can be realized with low excess entropy. Such photo-doped states are hard to access in theoretical simulations, because microscopic simulations typically do not reach long enough in time. We discuss theoretical approaches to directly address such low entropy photo-doped states in correlated materials. In particular, we demonstrate the emergence of eta-pairing superconductivity in the photo-doped Hubbard model.

12:00 p.m. Lunch/Departure