FM 56: Entanglement: Many-Body Dynamics II

Time: Wednesday 14:00–16:00 Location: 2004

Invited Talk FM 56.1 Wed 14:00 2004

New quantum many-body phases enabled by ergodicity breakdown — •Dmitry Abanin — University of Geneva, Geneve, Switzerland

The experimental advances in synthetic quantum systems, such as ultracold atoms, have enabled researchers to probe quantum thermalization and its breakdown. Thermalization occurs in ergodic systems and erases quantum information contained in the initial many-body states. Therefore, to create long-lived quantum states, it is of particular interest to find mechanisms of thermalization breakdown. One way of suppressing thermalization is by introducing strong quenched disorder, which induces many-body localization (MBL). MBL systems exhibit a new kind of emergent robust integrability and a wealth of novel dynamical phenomena. Surprisingly, MBL systems may also avoid heating under periodic driving, which opens up the possibility of having stable, Floquet-MBL phases with unusual properties. I will discuss one example of such a phase: a two-dimensional Anomalous Floquet Insulator, characterized by fully localized bulk states and chiral, thermalizing edge states.

Further, I will argue that MBL may not be the only way to break ergodicity. I will propose another mechanism, quantum many-body scarring, which bears a similarity to the well-known phenomenon of quantum scars in few-body chaos, and leads to a weaker form of ergodicity breaking that was recently observed in a many-body system of Rydberg atoms.

FM 56.2 Wed 14:30 2004

Development of a software based lock-in amplifier for phase-modulated spectroscopy — •Daniel Uhl, Friedemann Landmesser, Ulrich Bangert, Marcel Binz, Lukas Bruder, and Frank Stienkemeier — Institute of Physics, University of Freiburg, Germany

Recently, many-body effects of interacting molecules doped on rare gas clusters have been observed [1]. Detecting these weak higher order signals requires a particularly sensitive measurement scheme. We established such a method based on a phase modulated quantum beat experiment combined with lock-in detection to isolate multiple-quantum coherences (MQCs) in a low density alkali vapor [2,3]. Here, the MQC signatures show up at higher harmonics of the modulation frequency and can be extracted with harmonic lock-in detection. Hence, it is possible to simultaneously isolate several MQC signals in a single measurement using multiple lock-in amplifiers (LIA). To further improve our detection scheme we developed a software based LIA. This opens the possibility to demodulate our signal at different harmonics and thus gives us the advantage to observe any desired separate multiphoton processes in the pre-analysis. The algorithm is mainly based on a digital phase locked loop to detect the phase and frequency of the incoming reference signal. Hence, it is possible to demodulate the signal for different harmonics by conserving the phase information.

[1] S. Izadnia et al., J Phys Chem Lett 8, 2068 (2017)
[2] L. Bruder et al., Phys. Rev. A 92, 053412 (2015)
[3] L. Bruder et al., Phys. Chem. Chem. Phys. 21, 2276 (2019)

FM 56.3 Wed 14:45 2004

Many-body effects in cold molecules using phase-modulated two-dimensional coherent spectroscopy — •Friedemann Landmesser, Ulrich Bangert, Lukas Bruder, Marcel Binz, Daniel Uhl, and Frank Stienkemeier — Institute of Physics, University of Freiburg, Germany

Many-body quantum states are considered to play a crucial role in atomic and molecular systems with respect to dissipation, excitation and energy transfer (cf. [1]). We aim to investigate collective effects in organic molecules by multiple-quantum coherence experiments where multiphoton processes can be separated from one-photon transitions and can be assigned to specific particle numbers [2,3]. We will adapt a detection scheme based on phase-modulated two-dimensional coherent spectroscopy which was already used to investigate multi-atom Dicke states in potassium vapor [3,4]. Measurements on a rubidium vapor will serve as a benchmark. To study collective effects in organic molecular systems, we will adapt our helium nanodroplet source to produce solid rare gas clusters, that can be doped with hundreds of organic molecules. The cluster surface acts as a well-defined, cold environment [5]. In lifetime measurements we already identified collective effects of the interacting molecules at increasing doping densities [5].

[1] F. Fassioli et al., J. Royal Soc. Interface 11, 20130901 (2014).
[2] L. Bruder et al., Phys. Rev. A 92, 053412 (2015).
[3] S. Yu et al., Opt. Lett. 44, 2795 (2019).
[4] L. Bruder et al., Phys. Chem. Chem. Phys. 21, 2276 (2019).
[5] S. Izadnia et al., J. Phys. Chem. Lett. 8, 2068 (2017).

FM 56.4 Wed 15:00 2004

Dynamical driving a Cavity-BEC System from self-organized into non equilibrium — •Christoph Georges[1], Hans Kessler[1], Jayson G. Cosme[1,2], Ludwig Mathey[1,2], and Andreas Hemmerich[1,2] — [1]Institut für Laser-Physik and Zentrum für Optische Quantentechnologien, Universität Hamburg, D-22761 Hamburg, Germany — [2]The Hamburg Center of Ultrafast Imaging, Luruper Chaussee 149, D-22761 Hamburg, Germany

The generation and manipulation of density wave order in many body systems are considered as models for solid-state phenomena such as light-induced superconductivity.

In our recent research, we investigated the role of modulation on the formation of long-range order in a Cavity-Atom System. For this, a Bose-Einstein Condensate of Rubidium Atoms is placed inside the light field of a high finesse cavity. By pumping the atoms with a sufficient strong transversal optical standing wave, the system can go through a phase transition. The arising phase is characterized by an intracavity light field due to the formation of particle density waves [1].

By modulating the amplitude of pump field, the DW-order can either be suppressed [2] or new DW-orders can be excited [3]. In the present work, we modulated the light field with a frequency close to a collective resonance. We observe the excitation of a higher DW-order and the rise of a subradiant non-equilibrium phase.

[1] J. Klinder et. al. PNAS 112, 3290 (2015)
[2] Ch. Georges et. al. PRL 121, 220405 (2018)
[3] J. G. Cosme et. al. PRL 121, 153001 (2018)

FM 56.5 Wed 15:15 2004

Interacting bosons in an asymmetric double-well potential — •Jonathan Brugger and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Federal Republic of Germany

The fundamental equations of quantum mechanics are well-established, but their numerical solution can still be challenging, even for apparently simple quantum systems. Despite the ever increasing computational power available, new numerical and algorithmic approaches are key.

We investigate the quantum dynamics of two or more interacting bosons, trapped in an asymmetric double-well potential, by exact numerical diagonalization of their many-body Hamiltonian. Since the underlying Hilbert space is infinite-dimensional, we are seeking for an approximate solution in a subspace spanned by tensor products of polynomial B-Splines – an approach which has become popular over the last three decades in atomic and molecular physics.

FM 56.6 Wed 15:30 2004

Non-local emergent hydrodynamics in a long-range interacting spin system — •Alexander Schuckert[1,2], Izabella Lovas[1,2], and Michael Knap[1,2] — [1]Department of Physics and Institute for Advanced Study, Technical University of Munich, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, D-80799 München

Short-range interacting quantum systems with a conserved quantity exhibit universal diffusive behavior at late times in the absence of long-lived quasiparticle excitations. We show how this universality is replaced by a more general transport process in the presence of long-range interactions that decay algebraically with distance as $r^{-\alpha}$. While diffusion is recovered for large exponents $\alpha > 1.5$, longer-ranged interactions with $0.5 < \alpha \leq 1.5$ give rise to effective classical Lévy flights; a random walk with step sizes following a heavy-tailed distribution. We investigate this phenomenon in a long-range interacting XY spin chain, conserving the energy and the total magnetization, at infinite temperature by employing non-equilibrium quantum field theory and semi-classical phase-space simulations. We find that the space-time dependent spin density profiles are self-similar, with scaling functions given by the stable symmetric distributions. Moreover, autocorrelations show hydrodynamic tails decaying in time as $t^{-1/(2\alpha-1)}$ when $0.5 < \alpha \leq 1.5$. Our findings can be readily verified with current trapped ion experiments.

FM 56.7 Wed 15:45 2004

Entanglement and partial distinguishability in many-body systems — •Eric Brunner[1], Christoph Dittel[1], Gabriel Dufour[1,2], and Andreas Buchleitner[1] — [1]Quantenoptik und -statistik, Physikalisches Institut, Albert-Ludwigs-Universität Freiburg — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg

Exploring the structural properties of many-body interference in complex quantum systems plays a key role for an improved understanding and control of the underlying dynamics. Many-body interference in the involved constituents' dynamical degrees of freedom is controlled by their mutual (in)distinguishability. This, in turn, can be tuned by addressing suitable "labelling" degrees of freedom. Through a systematic analysis of correlations between dynamical and labelling degrees of freedom, we define a hierarchy of indistinguishability measures for general many-body states. To reveal those correlations, we identify robust features of many-body interference patterns and propose an experimentally feasible protocol to quantify partial distinguishability in generic non-interacting many-body systems.