Q 65: Many-body Physics

Time: Friday 11:00–13:00 Location: F342

Q 65.1 Fri 11:00 F342

Wave-particle duality of many-body quantum states — •Christoph Dittel[1,2,3], Gabriel Dufour[1,2], Gregor Weihs[4], and Andreas Buchleitner[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [3]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstraße 19, 79104 Freiburg, Germany — [4]Institut für Experimentalphysik, Universität Innsbruck, Technikerstraße 25, 6020 Innsbruck, Austria

We formulate a general theory of wave-particle duality for many-body quantum states, which quantifies how wavelike and particlelike properties balance each other. Much as in the well-understood single-particle case, which-way information – here, on the level of many-particle paths – lends particle character, while interference – here, due to coherent superpositions of many-particle amplitudes – indicates wavelike properties. We analyze how many-particle which-way information, continuously tunable by the level of distinguishability of fermionic or bosonic, identical and possibly interacting particles, constrains interference contributions to many-particle observables and thus controls the quantum-to-classical transition in many-particle quantum systems. The versatility of our theoretical framework is illustrated for Hong-Ou-Mandel-like and Bose-Hubbard-like exemplary settings.

Q 65.2 Fri 11:15 F342

Chiral edge dynamics of ultracold erbium atoms in a synthetic Hall system — Roberto Vittorio Röll, Arif Warsi Laskar, •Franz Richard Huybrechts, and Martin Weitz — Universität Bonn, Deutschland

The study of non-trivial topological phases of matter offers opportunities to produce platforms for interesting physics and plays an important role in the advancement of applications in the realm of quantum computing and information. Research on topologically protected edge states is currently being conducted due to their robustness with regards to smooth changes in the system's geometry. Here we report on the observation of chiral edge dynamics with an ultracold atomic erbium system in a synthetic 2D Hall ribbon, which is spanned by one internal and one external degree of freedom of the atoms. The topological nature of the system is confirmed by observing both closed and skipping orbits, and by determining the local Chern marker.

Q 65.3 Fri 11:30 F342

Ferromagnetism and Skyrmions in the Hofstadter-Fermi-Hubbard Model — •Felix A. Palm[1], Mert Kurttutan[2], Annabelle Bohrdt[3], Uli Schollwöck[1], and Fabian Grusdt[1] — [1]LMU Munich & MCQST, Munich, Germany — [2]Freie Universität Berlin, Germany — [3]Harvard University & ITAMP, Cambridge (MA), USA

Strongly interacting fermionic systems host a variety of interesting quantum many-body states with exotic excitations. For instance, the interplay of strong interactions and the Pauli exclusion principle can lead to Stoner ferromagnetism, but the fate of this state remains unclear when kinetic terms are added. While in many lattice models the fermions' dispersion results in delocalization and destabilization of the ferromagnet, flat bands can restore strong interaction effects and ferromagnetic correlations. To reveal this interplay, here we propose to study the Hofstadter-Fermi-Hubbard model using ultracold atoms. We demonstrate, by performing large-scale DMRG simulations, that this model exhibits a lattice analog of the quantum Hall ferromagnet at magnetic filling factor $\nu = 1$. We reveal the nature of the low energy spin-singlet states around $\nu \approx 1$ and find that they host quasiparticles and quasi-holes exhibiting spin-spin correlations reminiscent of skyrmions. Finally, we predict the breakdown of flat-band ferromagnetism at large fields. Our work paves the way towards experimental studies of lattice quantum Hall ferromagnetism, including prospects to study many-body states of interacting skyrmions and explore the relation to high-Tc superconductivity.

Q 65.4 Fri 11:45 F342

Many-particle interference in the tunneling dynamics of ultracold atoms experiencing dipole-dipole interactions — •Malte Henes[1,2], Andreas Buchleitner[1,2], and Christoph Dittel[1,2,3] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [3]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstraße 19, 79104 Freiburg, Germany

We study how dipole-dipole interactions affect many-particle interference in the tunneling dynamics of ultracold fermionic (^{87}Sr) (or bosonic ^{88}Sr) atoms, in a one-dimensional optical lattice or in an array of optical tweezers. The atoms' tunneling is considered as fully coherent, mediated by a Hubbard-like Hamiltonian, and dipole-dipole interactions, induced by the atoms' $^1S_0 \rightarrow {}^3P_0$ clock transition, are modelled through a master equation with a coherent, dispersive, and an incoherent, dissipative part. As a result of the interplay between dipole-dipole interactions and tunneling dynamics, we identify perfectly subradiant (dark) states for fermions, and find that the reduced visibility contrast in the particles' tunneling dynamics is indicative of the particles' partial distinguishability – induced by their dissipative interaction with the electromagnetic environment.

Q 65.5 Fri 12:00 F342

Aubry transition in chains of long-range interacting particles — •Raphaël Menu[1], Jorge Yago Malo[2], Maria Luisa Chiofalo[2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universit *at des Saarlandes, D-66123 Saarbr *ucken, Germany — [2]Dipartimento di Fisica Enrico Fermi, Universita di Pisa and INFN, Largo B. Pontecorvo 3, I-56127 Pisa, Italy

The celebrated Frenkel-Kontorova model provides a framework for understanding the onset of structures emerging from the interaction of a periodic crystalline structure with an underlying substrate with competing characteristic lengths. By tuning the depth of the substrate potential, the crystal undergoes a transition from a frictionless sliding on the surface to a pinned state. This is the so-called Aubry transition. While the classical picture of this model is well-understood, its quantum nature is still largely unexplored. Experimental realizations, such as chains of laser cooled trapped ions interacting with a periodic potential, are characterized by repulsive long-range interactions, for which the paradigm of the Frenkel-Kontorova model is only partially applicable.

In this work we analyze theoretically the dynamics at the Aubry transition for a chain of trapped ions interacting via the long-range Coulomb interaction.

Q 65.6 Fri 12:15 F342

Charge pumping in the anomalous Floquet topological insulator with Falicov-Kimball interactions — •Arijit Dutta[1], Tao Qin[2], and Walter Hofstetter[1] — [1]Goethe-Universität Frankfurt, Institut für Theoretische Physik, Frankfurt, Germany — [2]School of Physics and Optoelectronics Engineering, Anhui University, Hefei, Anhui Province 230601, People's Republic of China

The anomalous Floquet topological insulator (AFTI) is a unique phase found in periodically driven systems which hosts topological edge states even when the Chern number of the bulk band is zero. This results in quantized charge pumping in a nanoribbon geometry. Using Floquet-Keldysh DMFT we evaluate the efficiency of pumping in the AFTI phase in presence of Falicov-Kimball (FK) interaction and compare it with the corresponding results in the nonanomalous Floquet topological insulator - the so-called Haldane phase. We further discuss heating issues and relevance to experiments.

Q 65.7 Fri 12:30 F342

Nonlinear Response of Coherently Driven Atomic Arrays in the Discrete Truncated Wigner Approximation — •Christopher Mink and Michael Fleischhauer — University of Kaiserslautern-Landau

We derive a semiclassical approximation for the collective spontaneous and stimulated emission of an ensemble of driven two-level systems based on the discrete truncated Wigner approximation. In the case of totally symmetrical decay ("Dicke model") our method accurately re-

produces exact results including width and height of the superradiant burst and population trapping even at small ensemble sizes.

We then study the dynamics of square subwavelength atomic arrays of 14x14 atoms and the non-isotropic emission of photons of initially fully inverted arrays. Furthermore the nonlinear transmissivity and reflectivity in the presence of a classical driving field at varying intensities is determined.

Q 65.8 Fri 12:45 F342

Spin-Holstein Models in Trapped-Ion Systems — •Johannes Knörzer[1], Tao Shi[2], Eugene Demler[3], and Ignacio Cirac[4] — [1]Institute for Theoretical Studies, ETH Zurich, 8006 Zurich, Switzerland — [2]Chinese Academy of Sciences, Beijing 100190, China — [3]Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland — [4]Max Planck Institute of Quantum Optics, 85748 Garching, Germany

In this work, we highlight how trapped-ion quantum systems can be used to study generalized Holstein models, and benchmark expensive numerical calculations. We study a particular spin-Holstein model that can be implemented with arrays of ions confined by individual microtraps, and that is closely related to the Holstein model of condensed matter physics, used to describe electron-phonon interactions. In contrast to earlier proposals, we focus on simulating many-electron systems and inspect the competition between charge-density wave order, fermion pairing, and phase separation. In our numerical study, we employ a combination of complementary approaches, based on non-Gaussian variational ansatz states and matrix product states, respectively. We demonstrate that this hybrid approach outperforms standard density-matrix renormalization group calculations. At the end of the talk, I will give a perspective of interesting applications in quantum simulation.