Q 32: Quantengase (Gitter III)

Zeit: Donnerstag 8:30–10:15 Raum: 1C

Q 32.1 Do 8:30 1C

Coexistence of bosonic and fermionic atoms in a 3d optical lattice — •Thorsten Best, Sebastian Will, Ulrich Schneider, Lucia Hackermüller, Dries van Oosten, and Immanuel Bloch — Johannes Gutenberg-Universität Mainz

The investigation of mixtures of ultracold gases of distinct atomic species has gained a lot of attention recently. Depending on interaction strength and particle numbers, these systems can display rich phase diagrams with interesting analogies to condensed matter physics, especially in the presence of a periodic potential. We investigate a mixture of bosonic ^{87}Rb and fermionic ^{40}K atoms in a 3d optical lattice potential. Depending on the ratio of potassium to Rubidium atoms, the particle mobility in the lattice and the strength of interspecies interactions, we find evidence for coexistence or phase separation of the two species. We will present a characterization of the mixture in terms of both long-range coherence and onsite density distribution.

Q 32.2 Do 8:45 1C

Direct Observation and Control of Superexchange Interactions with Ultracold Atoms in Optical Lattices — •Stefan Trotzky[1], Patrick Cheinet[1], Simon Fölling[1,2], Michael Feld[1,3], Ute Schnorrberger[1], Ana Maria Rey[4], Anatoli Polkovnikov[5], Eugene Demler[2,4], Mikhail Lukin[2,4], and Immanuel Bloch[1] — [1]Johannes Gutenberg Universität Mainz — [2]Harvard University, USA — [3]Technische Universität Kaiserslautern — [4]Harvard-Smithsonian Center of Astrophysics, USA — [5]Boston University, USA

Quantum mechanical superexchange interactions form the basis of quantum magnetism in strongly correlated media. We report on the first direct observation of such superexchange processes with ultracold atoms in optical lattices. Our lattice set-up consists of a bichromatic superlattice along one spatial direction and two perpendicular monochromatic lattices, thus providing a three-dimensional array of double-wells. After preparing a spin-mixture of ^{87}Rb atoms in an antiferromagnetic order along the superlattice axis, we record the spin dynamics within the double-wells. In the regime of strong interaction, coherent superexchange oscillations are observed which can be described by an effective Heisenberg Hamiltonian. We demonstrate, how the effective coupling parameter can be controlled in magnitude and sign, thus enabling the system to be switched between ferromagnetic or antiferromagnetic spin interactions. The experimental results show very good agreement with the predictions of a two-site Bose-Hubbard model, however, we are also able to identify corrections, which can be explained by the inclusion of direct nearest-neighbor interactions.

Q 32.3 Do 9:00 1C

In situ studies of ultracold fermions in a blue detuned optical lattice — •Ulrich Schneider, Lucia Hackermüller, Thorsten Best, Sebastian Will, Dries van Oosten, and Immanuel Blocj — Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

Ultracold atoms in optical lattices are a versatile system to study topics ranging from ultracold molecules to solid state physics. The rich phase diagram of ultracold fermions in a lattice includes both metallic and insulating phases, e.g the fermionic Mott-Insulator and antiferromagnetically ordered states.

In our experiment we sympathetically cool fermionic ^{40}K with bosonic ^{87}Rb in an optically plugged quadrupole trap and subsequently in a dipole trap to quantum degeneracy. After removing the rubidium atoms from the trap, the fermionic ^{40}K is loaded into a blue detuned 3D optical lattice. The combination of a dipole trap and a blue lattice allows for an independent control of lattice depth and harmonic confinement. We use in situ imaging to study fermionic clouds in different regimes varying from noninteracting spinpolarized clouds to strongly interacting spin mixtures.

Q 32.4 Do 9:15 1C

Controlling interaction-induced dephasing of Bloch oscillations — •Elmar Haller, Mattias Gustavsson, Manfred Mark, Johann Danzl, Gabriel Rojas-Kopeinig, and Hanns-Christoph Nägerl — Institut für Experimentalphysik, Universität Innsbruck, Austria

A BEC in an optical lattice undergoes Bloch oscillations when subject to an external force. However, interactions lead to dephasing, limiting the number of oscillations one can observe.

By tuning the interaction strength using a Feshbach resonance, we quantitatively characterize the dephasing and compare with numerical simulations. The zero crossing of the scattering length can be precisely determined by minimizing dephasing. In the weakly interacting limit, we observe more than 20000 oscillations over 12 s.

For non-zero interaction strength, we find that the momentum distribution of a dephased condensate develops structure on a scale much smaller than the Bloch momentum. This structure becomes visible when the interaction is quickly switched off during release from the lattice and the time-of-flight detection is aided by magnetic levitation to allow for long expansion times.

Q 32.5 Do 9:30 1C

Exact phase-space dynamics of the M-site Bose-Hubbard model — •Friederike Trimborn, Dirk Witthaut, and Hans Jürgen Korsch — FB Physik, TU Kaiserslautern, 67663 Kaiserslautern

The dynamics of M-site, N-particle Bose-Hubbard systems is described in quantum phase space constructed in terms of generalized $SU(M)$ coherent states. These states have a special significance for these systems as they are equivalent to the fully condensed states. Based on the differential algebra developed by Gilmore, we derive an explicit evolution equation for the (generalized) Husimi (Q) and Glauber-Sudarshan (P) distributions. Most remarkably, these evolution equations turn out to be second order differential equations where the second order terms scale as $1/N$ with the particle number. For large N the evolution reduces to a (classical) Liouvillean dynamics. The phase space approach thus provides a distinguished instrument to explore the mean-field many-particle crossover.

Q 32.6 Do 9:45 1C

Mott-insulator states of ultracold atoms in optical resonators — Jonas Larson[1], Sonia Fernandez-Vidal[2], •Giovanna Morigi[2], and Maciej Lewenstein[1] — [1]ICFO - Institut de Ciencies Fotoniques, Castelldefels (Barcelona), Spain — [2]Departament de Fisica, Universitat Autonoma de Barcelona, 08193 Bellaterra, Spain

We investigate a paradigm example of cavity quantum electrodynamics with many body systems: an ultracold atomic gas inside a pumped optical resonator, confined by the mechanical potential emerging from the cavity-field spatial mode structure. When the optical potential is sufficiently deep, the atomic gas is in the Mott-insulator state as in open space. Inside the cavity, however, the potential depends on the atomic distribution, which determines the refractive index of the medium, thus altering the intracavity-field amplitude. We derive the effective Bose-Hubbard model describing the physics of the system in one dimension and study the crossover between the superfluid – Mott-insulator quantum states. We predict the existence of overlapping stability regions corresponding to competing insulator-like states. Bistable behavior, controlled by the pump intensity, is encountered in the vicinity of the shifted cavity resonance.

Q 32.7 Do 10:00 1C

Dynamics of the Ising chain coupled to a Markovian bath — •Birger Horstmann, Tommaso Roscilde, Michael Wolf, and Ignacio Cirac — Max-Planck-Institut für Quantenoptik, Garching

In this talk we discuss the dynamics of an Ising chain coupled to a Markovian bath. We simulate the dynamics of the system with a Lindblad master equation and study the decoherence of the ground state of the Ising chain in time focussing on the effect of the quantum phase transition of the Ising chain on the decoherence rates. We propose to simulate such a system in an optical lattice.