

Q 56: Quantengase (Fermionen und Gemische)

Zeit: Donnerstag 14:00–15:45

Raum: 6J

Q 56.1 Do 14:00 6J

Bose-Fermi-Hubbard-Modell im Grenzfall leichter Fermionen: eine effektive Theorie — ●ALEXANDER MERING und MICHAEL FLEISCHHAUER — Fachbereich Physik, Technische Universität Kaiserslautern, D-67663 Kaiserslautern

Wir stellen Rechnungen zum Bose-Fermi-Hubbard-Modell im Limes großen fermionischen Hoppings vor. Unter Verwendung der Born-Oppenheimer- und Markoff-Näherung ergibt sich ein effektiver Hamiltonoperator für die Bosonen. Dieser beschreibt ein erweitertes Bose-Hubbard-Modell mit unendlicher Reichweite, wobei die Dichte-Dichte-Kopplungskonstanten oszillieren und stark von der Fermionendichte sowie dem Abstand abhängen. Das resultierende Phasendiagramm beinhaltet mehrere unterschiedliche Phasen, welche numerisch diskutiert und durch eine exakte Diagonalisierung und mit DMRG-Methoden untersucht werden.

Q 56.2 Do 14:15 6J

Bloch oscillations of Fermi atoms in a 1D optical lattice — ●ALEXEY PONOMAREV¹, ANDREY KOLOVSKY^{1,2}, MING-CHIANG CHUNG¹, and ANDREAS BUCHLEITNER¹ — ¹Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden — ²Kirensky Institute of Physics, Ru-660036 Krasnoyarsk

We discuss the time dependent response of cold, non-polarized, fermionic atoms loaded in a 1D optical lattice to a static linear potential. Using Floquet-Bloch theory complemented by a perturbative analysis, we explain the dynamical properties of the fermions through the spectral characteristics of the Floquet-Bloch operator. A variety of unexplored dynamical regimes, such as periodic modulations of Bloch oscillations and the doubling of the Bloch frequency are described.

Q 56.3 Do 14:30 6J

Mixture of bosons and spin-polarized fermions in optical lattices — ●CORINNA KOLLATH¹, LOËDÉ POLLET², ULRICH SCHOLLWÖCK³, and MATTHIAS TROYER² — ¹University of Geneva, Switzerland — ²ETH Zürich, Switzerland — ³RWTH-Aachen, Deutschland

The physics in a mixture of bosonic and fermionic atoms confined to an optical lattice is very rich. Recently, two experimental groups succeeded in loading a mixture of bosonic and fermionic atoms into an optical lattice. The presence of a trapping potential makes the interpretation of the results difficult and controversial. We focus on the interplay of strong interparticle interactions, a trap, and finite temperature which leads to physics quite different from the homogeneous case. To name one example, we find a non-monotonous dependence of the visibility of the matter wave interference pattern after releasing the bosons from the optical lattice versus the lattice depth. This is in contrast to the experimental results and the difference can be resolved when taking into account heating while ramping up the lattice.

Q 56.4 Do 14:45 6J

Interacting Fermions in a 3D Optical Lattice — ●NIELS STROHMAIER¹, KENNETH GÜNTHER¹, YOSUKE TAKASU¹, HENNING MORITZ¹, MICHAEL KÖHL^{1,2}, and TILMAN ESSLINGER¹ — ¹Institute of Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland — ²Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

The Fermi-Hubbard model, which is an important element of modern condensed matter theory, can be experimentally explored with fermionic atoms in optical lattices. A particularly appealing feature is the capability to change smoothly from non-interacting to attractive or repulsive interactions by accessing a Feshbach scattering resonance. In the strongly repulsive case, one expects the formation of a fermionic Mott insulator state with reduced number fluctuations on each site. For attractive interactions superfluidity is predicted.

In our experiment, we prepare a spin mixture of ultracold fermions in a three-dimensional optical lattice at various filling factors. Recent results concerning the behaviour of the system for attractive as well as repulsive interactions will be presented.

Q 56.5 Do 15:00 6J

Energy spectrum of two interacting particles with unequal

trapping frequencies at an optical lattice site — ●FRANK DEURETZBACHER¹, KIM PLASSMEIER¹, DANIELA PFANNKUCHE¹, CHRISTIAN OSPELKAUS², SILKE OSPELKAUS², KLAUS SENGSTOCK², and KAI BONGS² — ¹I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstr. 9, 20355 Hamburg, Germany — ²Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We study fermionic ⁴⁰K atoms interacting with bosonic ⁸⁷Rb atoms at a single optical lattice site at a heteronuclear atomic Feshbach resonance [1] both experimentally and theoretically. We treat the interaction in terms of a regularized δ -function pseudopotential and consider the general case of particles with different trap frequencies, where the usual approach [2] of separating center-of-mass motion and relative motion fails. We numerically obtain the energy spectrum and the eigenfunctions from an exact diagonalization of the Hamiltonian. We find significant corrections to the energy not only due to the anharmonicity of the lattice site but also due to the different trap frequencies. Furthermore we calculate the transfer efficiency of the rf association and the lifetime of the molecules and compare our results with the experimental data. Finally we extend our study to other mixtures, such as ⁶Li and ¹³³Cs, where the effect is even larger.

[1] C. Ospelkaus *et al.*, Phys. Rev. Lett. **97**, 120402 (2006).[2] Th. Busch, B. G. Englert, K. Rzazewski, M. Wilkens, Found. Phys. **28**, 549 (1998).

Q 56.6 Do 15:15 6J

Heteronukleare Feshbach-Resonanzen in einer ultrakalten Bose-Fermi-Mischung — ●CARSTEN KLEMPPT, THORSTEN HENNINGER, OLIVER TOPIC, JOHANNES WILL, WOLFGANG ERTMER und JAN ARLT — Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, D-30167 Hannover

In den letzten Jahren wurden sowohl bosonische als auch fermionische Ensembles quantenentarteter Atome eingehend untersucht. Unser Experiment bietet die faszinierende Möglichkeit zum Studium gemischter Gase. In Zukunft sollen mit Hilfe einer heteronuklearen Feshbach-Resonanz aus dem atomaren Gasgemisch KRb-Moleküle gebildet werden.

Eine magneto-optische Falle wird mit bosonischem ⁸⁷Rb und fermionischem ⁴⁰K geladen. Ein bewegliches Spulenpaar transportiert die Atome in eine Magnetfalle, in der mittels Radiofrequenz-Evaporation eine quantenentartete Bose-Fermi-Mischung erzeugt werden kann. Das Ensemble kann in eine Dipolfalle umgeladen werden, um über ein starkes, homogenes Magnetfeld die heteronuklearen Feshbach-Resonanzen nachzuweisen. Die Position der Resonanzen wird mit aktuellen Ergebnissen anderer Gruppen und theoretischen Vorhersagen verglichen. Eine präzise Vermessung der Resonanzen trägt zum Verständnis des KRb-Molekülpotenzials bei. Eine genaue Kenntnis des Potentials und der zugehörigen Molekülzustände wird es in Zukunft ermöglichen, schwach gebundene Feshbach-Moleküle über ein oder mehrere Molekül-niveaus in stark gebundene Moleküle im absoluten Grundzustand zu überführen.

Q 56.7 Do 15:30 6J

Bose-Fermi Mixtures in a Three-Dimensional Optical Lattice — ●KENNETH GÜNTHER, THILO STÖFERLE, HENNING MORITZ, MICHAEL KÖHL, and TILMAN ESSLINGER — Institute of Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland

Optical lattices allow to enter the strongly correlated regime of ultracold bosons or fermions. A mixture of both species interconnects two systems of fundamentally different quantum statistics, and interesting phenomena such as the existence of polarons or a phase transition to a supersolid phase are expected.

We have studied mixtures of fermionic ⁴⁰K and bosonic ⁸⁷Rb quantum gases in a three-dimensional optical lattice. We observe that an increasing admixture of the fermionic species diminishes the phase coherence of the bosonic atoms as measured by studying both the visibility of the matter wave interference pattern and the coherence length of the bosons. Moreover, we find that the attractive interactions between bosons and fermions lead to an increase of the boson density in the lattice which we measure by studying three-body recombination in the lattice.