Q 7: Quantengase: Fermionen

Time: Monday 14:00–16:00 Location: V47.02

Q 7.1 Mon 14:00 V47.02

Dynamics of multi-component fermions in optical lattices — •Jasper Simon Krauser, Jannes Heinze, Nick Fläschner, Sören Götze, Christoph Becker, and Klaus Sengstock — Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg, Germany

Quantum gases in optical lattices offer a wide range of applications for quantum simulation due to the full control over lattice and interaction parameters as well as the internal atomic degrees of freedom. In our setup, we produce different interacting spin-mixtures of fermionic potassium atoms and load them into an optical lattice. The atoms behave similar to electrons in a crystal. However, in contrast to electrons with spin-1/2, we use ^{40}K with a higher spin, which has important effects on the properties of the system. The atomic ensemble is quenched from a polarized to a non-polarized regime and the resulting dynamics are recorded. We compare our data to a theoretical calculation. In the latter, we assume a simplified two-particle model which is in very good agreement with our observations. Our results open new perspectives to study magnetism of fermionic lattice systems beyond conventional spin-1/2 systems.

Q 7.2 Mon 14:15 V47.02

Pairing in a few-fermion system with attractive interactions — •Thomas Lompe[1,2], Gerhard Zürn[1,2], Friedhelm Serwane[1,2], Andre Wenz[1,2], Vincent Klinkhammer[1,2], and Selim Jochim[1,2] — [1]Physikalisches Institut, Universität Heidelberg — [2]MPI für Kernphysik, Heidelberg

Recently, our group has demonstrated the ability to prepare small samples of neutral fermionic atoms confined in an optical microtrap [1,2]. We can control the particle number and the motional quantum state of the particles with near unity fidelity. Here we report on our studies of systems consisting of atoms in two spin states with attractive interparticle interactions. We probe the system by deforming the trapping potential and observing the tunneling of particles out of the trap. We observe several signatures of pairing such as an increase of the tunneling time constants for stronger interactions and the appearance of pair correlations in the tunneling. With our tunneling measurements we also observe strong differences between systems with odd and even particle numbers. This is similar to the odd-even effect observed for the binding energies of nuclei.

[1] F. Serwane et al., Science 332, 336-338 (2011)
[2] G. Zürn et al., arXiv:1111.2727 (2011)

Q 7.3 Mon 14:30 V47.02

Conduction of ultracold Fermions through a mesoscopic channel — •David Stadler, Jean-Philippe Brantut, Jakob Meineke, Sebastian Krinner, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zürich, 8093 Zürich, Switzerland

We present a measurement of ultracold Fermions flowing through a horizontally oriented quasi 2-dimensional constriction which is connected to two macroscopic atom reservoirs. The constriction is made by a blue detuned laser beam that has a TEM01 mode, where atoms can only stay in a thin region of about 500nm between the two intensity maxima. A controlled imbalance of the number of atoms in the two reservoirs induces then a current of atoms from one side to the other. We observe the current of atoms as a function of time and see a characteristic decay of the atom number imbalance to its equilibrium position with equal atom number in both reservoirs. Secondly, we image the central part between the reservoirs where the 2-dimensional constriction is located. With our high-resolution imaging system we are able to measure in-situ the density distribution of atoms in the presence of a current. This gives us insight into the physical mechanisms that take place in the constriction and at the contacts to the reservoirs. We investigated the current of atoms in two very different situations. One is ballistic flow where we only have the quasi 2-dimensional constriction and the other is diffusive flow. Eventhough the macroscopic current of atoms is the same, we see a very different local behaviour of the atomic density in the constriciton and at the contacts.

Q 7.4 Mon 14:45 V47.02

Towards local probing of two-dimensional Fermi gases — •Wolf Weimer, Kai Morgener, Jan Henning Drewes, Niels Strohmaier, and Henning Moritz — Universität Hamburg, Institut für Laserphysik, Luruper Chaussee 149, 22761 Hamburg

Ultracold fermionic gases are an ideal model system for the study of quantum many-body phenomena. Of particular interest are two-dimensional strongly correlated systems which can exhibit superfluidity and Berezinskii-Kosterlitz-Thouless-type transitions.

Here we present our new experimental setup aimed at studying two-dimensional strongly interacting Fermi gases. Lithium atoms are cooled all-optically using an in vacuo bow-tie resonator for high transfer and cooling efficiency. The quantum degenerate gas will then be placed between two high resolution microscope objectives for local readout and control. The present status of the experiment will be discussed.

Q 7.5 Mon 15:00 V47.02

Fulde-Ferrel-Larkin-Ovchinnikov phase separation in a one-dimensional superconducting lattice of strongly coupled fermions — •Vivian França and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs Universität, Freiburg, Germany

The exotic coexistence of superconductivity and magnetism, first investigated by Fulde-Ferrell and Larkin-Ovchinnikov (FFLO), is predicted to show a spontaneous breaking of spatial symmetry. In spin-imbalanced fermionic systems, such inhomogeneous superfluidity manifests in a microscale phase separation, with alternating finite-momentum pairs and normal regions, the latter being composed by the excess species. After almost fifty years since the FFLO-phase was predicted, the microscale phase separation has not been observed. We deduce an expression for the critical polarization below which the FFLO-state emerges in a one-dimensional lattice with spin-imbalanced populations, and show that its ground-state is indeed microscale phase separated. For strongly interacting systems, we find that the microscale structure can be observed directly in the density profiles. Our results suggest that clear signatures of exotic superfluidity are accessible for state-of-the-art experiments with single-site resolution, as already achieved for bosons.

Q 7.6 Mon 15:15 V47.02

Ultracold Driven Fermigases: Population Trapping and Bloch Oscillations — •Regine Frank — Institut f\"ur Theoretische Festk\"orperphysik Wolfgang-G\"ade-Strasse 1, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

Ultracold gases are quite perfect to study physical systems under various aspects in situations far off the thermodynamical equilibrium. The two major reasons are that the properties of ultracold gases in optical lattices can be experimentally controlled almost without restrictions and the pronounced lack of dissipative coupling to the environment. We consider a three dimensional optical lattice whith strength modulations in time and loaded with an interacting gas of fermionic atoms. The inter-atomic correlation strength is varied from weak to strong and the temporal lattice modulations are taken into account by means of an non-equilibrium dynamical mean field theory (DMFT) incorporating the Keldysh Green's function technique. The numerical results for both the fluid (conducting) and the insulating regime, include the spectral weight function, the non-equilibrium distribution function, the optical conductivity and the relaxation time aof the excited atoms. We show the effects of population trapping in gapstates and Bloch oscillations of the ultracold fermions.

Q 7.7 Mon 15:30 V47.02

Robustness of Topological Operations with Ultracold Atoms — •Leonardo Mazza[1], Matteo Rizzi[1], Hong-Hao Tu[1], Mikhail Lukin[2], and J.Ignacio Cirac[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]Harvard University, Cambridge, USA

Since the discovery of the quantum Hall effect, topological states have influenced the research of diverse communities. Among their exotic properties, quasiparticles obeying unconventional statistics, called anyons, are surely one of the most seducing. Their braiding, i.e. controlled exchange of positions, has been proposed as a possible implementation for quantum computation.

Here we discuss the robustness against different sources of noise of information processing and storing of two topological models, the Majorana-Kitaev chain and the p+ip model. We also propose a setup based on fermionic atoms and molecules where both models are realized and anyons can be manipulated.

Q 7.8 Mon 15:45 V47.02

Low-Lying Excitation Modes of a Dipolar Fermi Gas: From Collisionless to Hydrodynamic Regime — •Falk Wächtler[1], Aristeu Lima[2], and Axel Pelster[3] — [1]Institut für Physik und Astronomie, Universität Potsdam, Germany — [2]Departamento de Física - Universidade Federal do Ceará, Fortaleza - Brazil — [3]Hanse-Wissenschatskolleg, Delmenhorst, Germany

By means of the Boltzmann-Vlasov equation we investigate dynamical properties of a trapped dipolar Fermi gas. In order to determine an approximative solution, we follow Ref. [1] and rescale both space and momentum variables, thus obtaining ordinary differential equations for the respective scaling parameters. Then, we procced by linearizing these equations around the equilibrium in order to study the low-lying excitations of the system. Within the relaxation-time approximation for the collisional integral, our approach is able to describe the low-lying excitations all the way from the collisionless [2] to the hydrodynamic [3] regime.

[1] P.Pedri, D. Guery-Odelin, and S. Stringari, Phys. Rev. A **68** 043608 (2003).
[2] T. Sogo, L. He, T. Miyakawa, S. Yi, H. Lu, and H. Pu, New J. Phys. **11**, 055017 (2009).
[3] A.R.P. Lima and A. Pelster, Phys. Rev. A **81**, 021606(R) and 063629 (2010).