Q 52: Quantum gases: Fermions

Time: Thursday 14:00–15:45 Location: F 342

Group Report Q 52.1 Thu 14:00 F 342

Dynamical Properties of High-Spin Fermionic Quantum Gases — •Jasper Simon Krauser, Jannes Heinze, Nick Fläschner, Klaus Sengstock, and Christoph Becker — Universität Hamburg, Institut für Laserphysik, Luruper Chaussee 149, 22761 Hamburg, Germany

Ultracold fermions with large spin provide ideal model systems for high-spin magnetic properties beyond conventional electronic magnetism. Here, we report on extensive studies of fundamental spin and spin-spatial excitations in high-spin Fermi mixtures: Coherent multi-flavour spin dynamics in bulk systems and in 3d optical lattices, multi-component spin waves as well as the tuning of spin interactions via Feshbach resonances. As a key result we find that ultralow temperatures are essential for the coherent nature of spin dynamics. For our observations we find excellent agreement with theoretical models. Our results open new perspectives for further studies of high-spin magnetic properties such as $S > 1/2$ Mott insulators or color superfluidity. This work is supported by DFG within FOR 801.

Q 52.2 Thu 14:30 F 342

A Single Impurity in a Finite Fermi Gas — •Andre N. Wenz, Gerhard Zürn, Simon Murmann, Vincent Klinkhamer, Andrea Bergschneider, Thomas Lompe, and Selim Jochim — Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg

We have studied ultracold fermionic few-particle systems consisting of one single impurity atom and an increasing number of majority atoms in another spin state. Starting from one atom in each spin state we observe the convergence of the normalized interaction energy towards a many-body limit by increasing the number of atoms one by one.

We realize this with a system of fermionic ^{6}Li atoms trapped in a quasi 1D optical dipole potential. In this system we can tune the strength of the repulsive interaction between the impurity and the majority atoms using a confinement induced resonance and probe the system by radio-frequency spectroscopy. This allows us to measure the interaction energy as a function of the number of majority atoms. We find that the interaction energy for a two particle system with one atom per spin state is very well described by the analytic theory by T. Busch et al. (Found. of Phys. 28, 549 (1998)). For an increasing number of majority atoms the interaction energy shows good agreement with numerical few-body calculations. For more than three majority atoms the normalized interaction energy quickly converges to a many-body limit. This limit is close to the prediction from an analytic model describing a single impurity in a bath of fermions which we obtain by adapting the homogeneous solution of McGuire (JMP 6, 432 (1965)) to the trapped system.

Q 52.3 Thu 14:45 F 342

Self-bound one-dimensional dipolar Fermi gases — •Frank Deuretzbacher[1], Georg M. Bruun[2], Mattia Jona-Lasinio[1], Christopher J. Pethick[3], Stephanie M. Reimann[4], and Luis Santos[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Germany — [2]Department of Physics and Astronomy, University of Aarhus, Ny Munkegade, 8000 Aarhus, Denmark — [3]The Niels Bohr International Academy, The Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen, Denmark — [4]Mathematical Physics, LTH, Lund University, 22100 Lund, Sweden

Dipolar Fermi gases open qualitatively novel scenarios compared to non-dipolar systems. We show that when the dipole moment is strong enough, self-bound single-component Fermi clouds may be possible in quasi-one-dimensional geometries due to the competition between the attractive dipole-dipole interaction and the Fermi pressure. By means of the Thomas-Fermi-Dirac approximation we establish the universal conditions for the existence of these states, showing that they are reachable in future experiments with ultra-cold polar molecules.

Q 52.4 Thu 15:00 F 342

Observation of Ferromagnetic Spin Correlations in a 1D Fermi System — •Simon Murmann, Andre N. Wenz, Vincent Klinkhamer, Andrea Bergschneider, Gerhard Zürn, Thomas Lompe, and Selim Jochim — Physikalisches Institut der Universität Heidelberg

We have studied spin correlations of quasi 1D spin $\frac{1}{2}$ systems. Starting with a ground state system of three to five ultracold ^{6}Li atoms, we use a Feshbach resonance to introduce repulsive interactions between the particles. After an adiabatic ramp across the resonance the particles end up in metastable states which have higher energies than states of spin-polarized samples with the same atom number. For systems satisfying this criterion the Stoner model predicts a transition to a ferromagnetic state. As a probe for the spin correlations, one particle is allowed to escape from the trap and the z-component of the total spin, as well as the energy of the remaining atoms is measured.

For weak repulsive interactions no significant fraction of prepared systems end up in a spin-polarized final state. This anticorrelation between the spins decreases with increasing repulsion. When crossing the Feshbach resonance to the metastable branch the number of spin-polarized systems is strongly enhanced, indicating the presence of strong ferromagnetic correlations.

Q 52.5 Thu 15:15 F 342

Quenching into the quantum AF]{Quenching into the quantum antiferromagnetic phase of ultra-cold fermions — •Monika Ojekhile, Robert Höppner, Ludwig Mathey, and Henning Moritz — University of Hamburg

The quantum anti-ferromagnetic phase of the two-dimensional Heisenberg model is one of the quintessential phases of many-body physics. To create and study this phase experimentally in ultra-cold fermionic atoms is one of the main challenges in the field of ultra-cold atoms. One important obstacle in these experiments are the high-entropy edge regions in the atomic trap, which can lead to substantial heating of the sample when the system is manipulated in a slow, adiabatic manner to create the phase.*Here, we study if and how this phase can be created by a fast quench instead. We consider several realistic quenches of the lattice parameters and external fields, as well as*several initial states, as ingredients of the quench.*We estimate the amount of excitations created in the quench using spin wave theory, and thereby*determine what the optimal strategy is to reach the quantum anti-ferromagnetic phase.

Q 52.6 Thu 15:30 F 342

Production of Ultracold Gases of Ytterbium in a 2D-/3D-MOT Setup — •Sören Dörscher, Alexander Thobe, Bastian Hundt, André Kochanke, Christoph Becker, and Klaus Sengstock — Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Quantum gases of two-electron atoms are an exciting new branch within the field of ultracold atoms. Due to their complex level structure and unique features new phenomena such as SU(N)-symmetric spin Hamiltonians, artificial gauge fields or the Kondo lattice model can be studied.

Here we report on a novel experimental setup to produce quantum degenerate Yb gases based on a 2D-/3D-MOT scheme without use of a Zeeman slower. The 2D-MOT operated on the strong $^1S_0 - {}^1P_1$ transition captures Yb directly from a thermal beam of atoms and loads a 3D-MOT on the narrow $^1S_0 - {}^3P_1$ intercombination transition. Subsequently, atoms are transferred into a crossed optical dipole trap and evaporatively cooled to quantum degeneracy. We routinely produce Bose-Einstein condensates of ^{174}Yb with $1 \cdot 10^5$ atoms and degenerate Fermi gases of the spin-5/2 isotope ^{173}Yb with typically $2 \cdot 10^4$ particles at $T/T_F = 0.35$. We then prepare and study the ultracold gases in a triangular optical lattice by spectroscopy on the ultranarrow $^1S_0 - {}^3P_0$ transition.

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