Q 51: Quantum Gases: Fermions

Time: Thursday 14:00–16:15 Location: E 001

Q 51.1 Th 14:00 E 001

Collective Motion of Polarized Dipolar Fermi Gases in the Hydrodynamic Regime — Aristeu Rosendo Pontes Lima[1] and •Axel Pelster[2,3] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Institut für Physik und Astronomie, Karl-Liebknecht-Str. 24 14476 Potsdam, Germany — [3]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

Recently, a seminal STIRAP experiment allowed the creation of $^{40}K^{87}Rb$ molecules in the rovibrational ground state [1]. In order to describe such a polarized dipolar Fermi gas in the hydrodynamic regime, we work out a variational time-dependent Hartree-Fock approach [2]. With this we calculate dynamical properties of such a system as, for instance, the frequencies of the low-lying excitations and the time-of-flight expansion. We find remarkable effects of a strong dipole-dipole interaction such as anisotropic breathing oscillations in momentum space and a suppression of the aspect-ratio inversion after release of the harmonic trap.

[1] K.-K. Ni *et al.*, Science **322**, 231 (2008)
[2] A. R. P. Lima and A. Pelster, arXiv:0908.4583

Q 51.2 Th 14:15 E 001

Quantum solitons of spin-3/2 fermions in 1D optical lattices — •Arturo Argüelles and Luis Santos — Institut für Theoretische Physik, Leibniz Universität Hannover, Hannover, Deutschland

In this presentation we analyze the dynamics of spin-3/2 fermions in optical lattices, and in particular how this dynamics is affected by the quadratic Zeeman effect for different interaction regimes. In particular we shall present recent results on Matrix-Product-States simulations of the dynamics of hard-core spinor fermions. After briefly commenting on the possibility to have different spin-wave velocities, we shall discuss in detail the creation under proper conditions of quantum solitons. These quantum solitons are dimers at neighboring sites, which propagate without unbinding. The binding of the pair (which resembles a Peierls-Nabarro barrier) is induced by the interplay between quadratic Zeeman effect and spin-changing collisions. After discussing the existence and lifetime of these quantum solitons, we shall comment on soliton-soliton collisions, howing that the typical time for inelastic collisions (that destroy one of the two colliding solitons) is equal or larger than the soliton life-time, showing that the system can hold a meta-stable quantum-soliton gas.

Q 51.3 Th 14:30 E 001

Local probing of a degenerate Fermi gas — •Jakob Meineke, Bruno Zimmermann, Torben Müller, David Stadler, Henning Moritz, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, Hönggerberg HPF D21, 8093 Zürich, Switzerland

Ultracold atomic gases are ideal systems to study many-body quantum physics. The development of new probes offers the possibility to extract more information from these systems. We have developed an apparatus that allows local probing of a degenerate Fermi gas with a resolution of 700 nm. We prepare an optically trapped gas of degenerate ^{6}Li atoms in a glass cell sandwiched between two microscope objectives. This setup allows us not only to shape potentials on the scale set by the resolution of the microscopes, but also to probe the state of the atomic ensemble *in-situ* with high resolution. In this talk we will present results obtained by studying atom number fluctuations of the degenerate atomic cloud.

Q 51.4 Th 14:45 E 001

Is it possible to access the strongly interacting regime with a $^{6}Li^{40}K$ Fermi-Fermi mixture? — •Andreas Trenkwalder[1], Christoph Kohstall[1,2], Frederik Spiegelhalder[1], Devang Naik[1], Gerhard Hendl[1], Florian Schreck[1], and Rudolf Grimm[1,2] — [1]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Austria — [2]Institut für Experimentalphysik und Zentrum für Quantenphysik, Universität Innsbruck, Innsbruck, Austria

Interspecies Feshbach resonances in the $^{6}Li^{40}K$ Fermi-Fermi mixture are closed-channel dominated and quite narrow. In order to determine if it is experimentally feasible to realize the strongly interacting regime, we measure the elastic and inelastic scattering properties across one of the widest interspecies resonances. Preliminary results are promising and indicate that the strongly interacting regime can indeed be reached.

Q 51.5 Th 15:00 E 001

Nonequilibrium transport of fermions through an Anderson quantum dot — •Denes Sexty — Institut fuer Theoretische Physik, Heidelberg, Deutschland

The non-equilibrium time evolution of an Anderson quantum dot coupled between two lead-reservoirs forming a chemical-potential gradient for fermions is investigated. We use Kadanoff-Beym dynamic equations derived from the two-particle irreducible effective action. The method allows the determination of the non-equilibrium (transient) as well as stationary transport through the quantum dot, and results are compared to pure perturbative approximations for different values of the interactions between the fermions. Our aim is to study the non-equilibrium transport in the Kondo regime in the framework of an extended renormalization-group treatment.

Q 51.6 Th 15:15 E 001

Phase diagram of a spin-imbalanced Fermi mixture in 1D — •Ann Sophie C. Rittner, Yean-an Liao, Tobias Paprotta, and Randall G. Hulet — Department of Physics and Astronomy and Rice Quantum Institute, Rice University, Houston, TX 77251,

The search for the Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) phase, a polarized superfluid with a spatially varying order parameter, has generated large interest in both the condensed matter and cold atoms communities. To date, there has been only indirect experimental evidence of FFLO in the heavy fermion superconductor $CeCoIn_5$. In a 1D polarized Fermi gas, the FFLO phase is predicted to occupy a large region of the phase diagram (G. Orso, Phys. Rev. Lett. 98, 070402 (2007)). We have implemented a 2D optical lattice in order to explore the phase diagram of an imbalanced spin mixture of ^{6}Li. In-situ density distributions show a partially polarized region at the center of the cloud surrounded by an either fully polarized Fermi gas or an unpolarized superfluid shell depending on the polarization of the cloud. The density profiles are quantitatively well-described by a non-zero temperature Bethe ansatz calculation and can be used to extract the 1d phase diagram of the imbalanced 1d Fermi gas (Y.-a. Liao *et al.*, arXiv:0912.0092). Moreover, the quantitative agreement of experiment and theory provides evidence for the existence of the elusive FFLO phase in this system.

Q 51.7 Th 15:30 E 001

Mott insulator phases of spin-3/2 fermions in one-dimensional lattices. — •Karen Rodríguez, Arturo Argüelles, Maria Colomé-Tatché, Temo Vekua, and Luis Santos — Institut für Theoretische Physik, Leibniz Univesität Hannover, Hannover,Deutschland

We study the ground state phase diagram of repulsive spin-3/2 fermions at zero magnetization in the presence of quadratic Zeeman effect(QZE). Starting from the Hamiltonian of the four-component Hubbard model we derive the effective hard-core Hamiltonian, that can be understood as a spin-chain model. This model presents effective coupling constants which show a non-trivial dependence induced by the interplay between quadratic Zeeman effect and spin-changing collision. In the absence of a quadratic Zeeman effect the ground state of the system is either in the dimer (spin Peierls) phase or in the spin liquid one. Applying a non-zero quadratic Zeeman effect the system breaks the degeneracy between the 1/2 and the 3/2 spin components, resulting in a phase transition into an effective pseudo-spin 1/2 isotropic Heisenberg antiferromagnet for a sufficiently large QZE. We characterize by means of DMRG calculations the ground state properties, including spin-spin and dimer-dimer correlations, magnetization gap and chirality, for the different regimes and determine the boundaries between the different phases. We characterize the transition between dimer phase and effective Heisenberg antiferromagnet by means of exact diagonalization techniques.

Q 51.8 Th 15:45 E 001

Feshbach resonances in Fermi mixtures of ultracold ^{40}K — •Antje Ludewig[1], Tobias Tiecke[1], Steve Gensemer[1,2], Sebastian Kraft[1,3], and Jook Walraven[1] — [1]Van der Waals-Zeeman Institute of the University of Amsterdam, The Netherlands — [2]Ethel Walker School, Simsbury, United States — [3]PTB, Braunschweig

We report on the measurement of Feshbach resonances in ultracold Fermi-Fermi mixtures of ^{40}K in an optical dipole trap (ODT). In the same trap we have realized degenerate spin mixtures of 10^6 ^{40}K atoms at T=0.3(1)T_F. The cold atoms are loaded from a two dimensional magneto optical trap (MOT). After evaporation in an optically plugged magnetic trap the ^{40}K atoms are loaded into optical tweezers and transported over a distance of 21.5cm into a science cell. Using microwave radiation and resonant light we prepare non degenerate mixtures of $2 * 10^5$ ^{40}K atoms in various Zeeman states. ^{40}K has a rich hyperfine structure (F=9/2) and many Feshbach resonances involving the different states are expected. We measure these resonances using magnetic field coils designed for high homogeneity. We report on our progress exploring Feshbach resonances in ^{40}K and locating resonances favourable for the investigation of many body states.

Q 51.9 Th 16:00 E 001

Quantum fluid in bilayers of ultra-cold polar Fermi molecules

— Michael Klawunn, •Alexander Pikovski, and Luis Santos — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Germany

Quantum degenerate cold molecules with a strong electric dipole moment may soon be within experimental reach. We study a system of ultracold polar Fermi molecules confined into two neighboring layers, e.g. in a two-well potential. The main interaction between these layers is provided by the dipole-dipole forces (all dipoles are polarized in one direction). It is found that in the quantum degenerate regime, the interaction may lead to the formation of Cooper-like pairs, where a molecule in layer 1 is paired with a molecule in layer 2. We discuss the appearance of this paired state and give an outlook to future work.