A 13: Poster II

Time: Tuesday 18:00–20:00 Location: P1

A 13.1 Tue 18:00 P1

Diffraction patterns of ensembles of small molecules — •Martin Winter, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik koplexer Systeme

Upcomming X-ray free-electron lasers produce radiation with a high brilliance at Angstrom wavelengths. These sources can image molecules with a resolution down to the atomic scale. However, since the cross sections of the interaction are small, the resulting diffraction patterns will be very faint. The retrieval of the molecular structure out of many faint diffraction images is very challenging [1].

Therefore we propose a new method to determine the structure of small molecules from their diffraction patterns. From their incoherent sum, all intra-molecular distances and their multiplicities are extracted. This leads to a multidimensional turnpike problem which we tackle by two different methods: a backtracking strategy proposed by Skiena et al. [2] and a variation of the satisfiability problem using multidimensional scaling.

[1] K.J. Gaffney and H.N. Chapman, Science 316, 1444 (2007).
[2] S. Skiena, W. Smith and P. Lemke, Proceeding SCG, doi:10.1145/98524.98598

A 13.2 Tue 18:00 P1

Collapse and Revival and Trap-induced Dynamics in Bosonic Lattice Systems — •Michael Buchhold[1], Ulf Bissbort[1], Sebastian Will[2,3], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, 60438 Frankfurt/Main — [2]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München — [3]Max-Planck-Institut für Quantenoptik, 85748 Garching

The recently achieved long-time observation of collapse and revival dynamics of a Bose-Einstein condensate loaded into a three-dimensional optical lattice allows to directly reveal the presence of effective coherent multi-particle interactions, generated via transitions to higher lattice orbitals.

To theoretically describe the collapse and revival dynamics of a BEC in an inhomogenous optical lattice, an effective single-band Hamiltonian in the Gutzwiller approximation is used, which includes transitions to higher bands by the use of renormalized parameters.

We study the interplay between quantum dynamics induced by the presence of a confining trap potential and the collapse and revival dynamics. We demonstrate that, with high accuracy, the dynamics in a ramped-up lattice can be described within a single particle picture, although inter-site tunneling is almost completely suppressed.

A 13.3 Tue 18:00 P1

Chromium Bose-Einstein condensates in multi-well potentials — •Juliette Billy, Stefan Müller, Emanuel Henn, Holger Kadau, Philipp Weinmann, David Peter, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

To probe the long-range anisotropic dipolar interaction (DI) in chromium Bose-Einstein condensates (BECs), we aim to extend the geometry-dependent stability diagram of dipolar BECs [1] to highly oblate traps. Experimentally we slice a condensate into several pancake shaped clouds using a 1D optical lattice and investigate the stability of the system, comparing it to theoretical calculations. Our results support significant coupling between neighboring layers through the DI. For further investigating this coupling, we plan a second experiment to study the minimal system consisting of a dipolar BEC trapped in a triple-well potential [2]. The experimental realization of such a system implies major upgrades of our apparatus, which we detail here.

[1] T. Koch *et al.*, Nature Physics **4**, 218 (2008)
[2] T. Lahaye *et al.*, Phys. Rev. Lett. **104**, 170404 (2010)

A 13.4 Tue 18:00 P1

Theory of a dipolar quantum gas in a multi-well potential — •David Peter[1], Krzysztof Pawłowski[2], Kazimierz Rzazewski[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart — [2]Center for Theoretical Physics, Polish Academy of Sciences, Warsaw

We investigate the physics of dipolar bosons in a multi-well potential, generalizing what has been done for the triple-well system in [1]. Due to the non-local character of the dipolar interaction and the finite size of the system, inter-site effects are crucial and lead to a large variety of ground states – some of them not being apparent in the triple-well system. These calculations are also applicable to the situation where a dipolar Bose-Einstein condensate is loaded into a 1D optical lattice with a large number of sites occupied.

[1] T. Lahaye *et al.*, Phys. Rev. Lett. **104**, 170404 (2010)

A 13.5 Tue 18:00 P1

Self-organized phase of strongly interacting Bose gases in an optical cavity — •Yongqiang Li, Liang He, and Walter Hofstetter — Johann Wolfgang Goethe Universität Frankfurt (Main)

Motivated by a recent experiment on the BEC-cavity system [1] in which a self-organization phase transition was realized in an open system formed by a Bose-Einstein condensate coupled to an optical cavity, we numerically simulate an ultracold Bose gas in a high-finesse optical cavity by means of real-space Bosonic Dynamical Mean Field Theory [2]. We observe the phase transition from a normal to a self-organized phase and investigate the influence of superfluidity and thermal fluctuations on the self-organized phase in an optical cavity without a harmonic trap. In the presence of a harmonic trap, the coexistence of superfluid, mott-insulating and self-organized phase is observed. We find that the appearance of the wedding-cake density distribution of strongly-interacting Bose gases plays an important role on the buildup of the self-organized phase.

[1] K. Baumann, C. Guerlin, F. Brennecke and T. Esslinger, Nature **464**, 1301 (2010).
[2] Y. Li, L. He, W. Hofstetter, in preparation.

A 13.6 Tue 18:00 P1

Entropy role on the size of an atomic Fermi gas in an optical lattice — •M.Reza Bakhtiari[1], Bernd Schmidt[1], Irakli Titvinidze[1], Michiel Snoek[2], Ulrich Schneider[3], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Johann Wolfgang Goethe–Universität, 60438 Frankfurt/Main, Germany — [2]Institute for Theoretical Physics, Valckenierstraat 65, 1018 XE Amsterdam, The Netherland — [3]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München, Germany

We theoretically investigate the thermodynamic properties of an inhomogeneous Fermi gas in a 3D optical lattice. We study the interplay between the strong correlation effects and the entropy of the trapped gas. Upon increasing the attractive interaction, this interplay leads to an anomalous expansion in size of the atomic cloud. We model the system by an inhomogeneous Fermi-Hubbard model and we apply a Dynamical Mean-Field Theory (DMFT) combined with a Local Density Approximation to compute the atomic density, superfluid order parameter, entropy and the atomic cloud size. Whenever applicable, we also compare DMFT findings with the result of a high-temperature expansion. Our results show a good agreement with the experiment [1] in which the anomalous expansion of a trapped Fermi gas was observed.

[1] L. Hackermüller *et al.*, Science **327**, 1621 (2010).

A 13.7 Tue 18:00 P1

Matter wave guiding through a photonic bandgap fiber — •Hannes Duncker, André Wenzlawski, Lars Wacker, Patrick Windpassinger, and Klaus Sengstock — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

In this contribution, we present a project where we intend to study light-matter interaction in an extremely one-dimensional geometry. Ultracold atoms are loaded into a hollow core photonic bandgap (HCPBG) fiber. As a first step, we have been able to demonstrate guiding of cold, slow atoms through an 88 mm long piece of fiber [1]. The guiding potential is created by a far-off resonance dipole trap which propagates in the hollow core of the HCPBG fiber. By imaging the guided atoms' fluorescence signal, we observe a peak atomic flux of 1.2×10^5 atoms/s. Combined with new cooling techniques, single mode operation of the waveguide should be achievable which would pave the way towards guided matter wave interferometry. Furthermore, the tight confinement allows for strong light-atom coupling in a well defined optical potential over macroscopic distances.

[1] S. Vorrath et al, NJP (in press, 2010), Preprint arXiv:1010.0101

A 13.8 Tue 18:00 P1

Experiments with ultracold atomic mixtures in optical lattices — •Daniel Pertot[1], Bryce Gadway[1], Jeremy Reeves[1], Rene Reimann[1,2], and Dominik Schneble[1] — [1]Department of Physics & Astronomy, Stony Brook University, Stony Brook, NY 11794, USA — [2]Present address: Institut für Angewandte Physik, Universität Bonn, 53115 Bonn, Germany

Quantum gases in optical lattices allow for fundamental studies in atomic and condensed-matter physics. We have performed several experiments with binary homonuclear atomic mixtures (derived from a Bose-Einstein condensate) in lattices whose depth can be independently controlled for each component. Interactions in the mixture lead to novel features: collinear atomic four-wave mixing [1], polaronic effects in the strongly correlated regime [2], and scattering from crystalline atomic structures.

[1] D. Pertot et al., Phys. Rev. Lett. 104, 200402 (2010) [2] B. Gadway et al., Phys. Rev. Lett. 105, 045303 (2010)

A 13.9 Tue 18:00 P1

Pair Correlations in Low-Dimensional Ultracold Quantum Gases — •Arne Ewerbeck, Matthias Scholl, Andreas Vogler, Peter Würtz, Vera Guarrera, Giovanni Barontini, and Herwig Ott — Fachbereich Physik, Technische Universität Kaiserslautern

We present an experimental approach for in-situ correlation measurements in ultracold gases. In our experiment we ionize atoms of an atomic ensemble by electron impact ionization, using a tightly focussed electron beam. The ions are extracted by means of electrostatic optics and subsequently detected. This allows us to probe density distributions with high spatial resolution. Furthermore, by analyzing the temporal sequence of ion signals, we aim to determine the pair correlation function of trapped one- and twodimensional quantum gases. A combination of optical dipole-traps is used to confine the atoms in a low-dimensional geometry. The current status of the experiment is presented.

A 13.10 Tue 18:00 P1

Preparation and characterization of cold fermionic gases in optical lattices — •Daniel Greif, Thomas Uehlinger, Leticia Tarruell, Gregor Jotzu, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, Switzerland

Ultracold atoms in optical lattices are an almost ideal realization of the celebrated Hubbard Hamiltonian, which is a central model in strongly correlated condensed matter systems. The recent advance in control of fermionic quantum gases makes these systems a promising candidate to study the low temperature regime. This requires both development of sensitive probes on magnetic correlations and novel schemes for preparation of low entropy states in the lattice. We report on measurements of nearest-neighbor correlations, which can be used to detect local spin ordering, and recent progress on preparation of cold fermionic gases in the lattice.

A 13.11 Tue 18:00 P1

Contolling a bond with light: Ultralong-range Rydberg molecules — •Johannes Nipper, Björn Butscher, Jonathan Balewski, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Germany

We report on experiments exploring ultralong-range Rydberg molecules. These unusual bound states between Rydberg atoms and ground state atoms feature novel binding mechanisms based on low energy electron scattering as well as internal quantum reflection at a shape resonance of electron-atom scattering [1].

Besides the binding energies of dimer and trimer states, further properties are studied in high resolution spectra in the high density regime. This extends from density dependend lifetime measurements to experiments in electric fields that reveal a molecular Stark effect due to a permanent electric dipole moment of the molecules.

The possibility to coherently control this binding mechanism is shown in Rotary echo and Ramsey experiments and the coherence times are extracted [2].

[1] V.Bendkowsky et.al., PRL 105, 16 (2010)
[2] B.Butscher et.al., Nature Physics, nphys1828 (2010)

A 13.12 Tue 18:00 P1

Many body physics using Strontium lattice — •Rick Mukherjee[1], James Millen[2], Matthew Jones[2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Physics, Durham University, United Kingdom

We explore prospects for optical lattice confinement of Strontium Rydberg atoms. In particular we identify a magic frequency in the bluedetuned spectrum which allows for simultaneous trapping of ground and Rydberg states and show that the overall lifetime of such systems is only limited by spontaneous decay. Further, it is found that the Strontium nS states feature attractive van der Waals interactions, which is used to devise a scheme for the robust generation of manybody Schroedinger cat states. The latter exemplifies the potential of the described approach for quantum information schemes and metrology by exploiting the extreme interactions between Rydberg atoms.

A 13.13 Tue 18:00 P1

Ultracold Rydberg Molecules — •Iris Reichenbach[1], Weibin Li[2], and Jan-Michael Rost[1] — [1]Max Planck Institut für Physik komplexer Systeme, Dresden, Germany — [2]University of Nottingham, Nottingham, UK

Recently, there has been considerable interest in Rydberg molecules, that is molecules involving one Rydberg atom and a ground state atom or molecule. [1,2,3] This is due to the large size, high polarizability and low binding energy of such molecules, which allow for control of the resulting states and interactions. Furthermore, the unique properties of these molecules allows for basic research in ultracold chemistry, as well as a more detailed examination of ultracold scattering processes, ultracold gases and possible applications in quantum information processing. We focus here on a molecule consisting of one Rydberg atom and one ground state dimer, and examine the dependence of the resulting state on the details of the constituents, such as their relative orientation.

[1] C. H. Greene et al, PRL 85, 2458 (2000).
[2] V. Bendkowsky et al, Nature (London) 458, 1005 (2009).
[3] V. Bendkowsky et al. PRL 105, 163201 (2010).

A 13.14 Tue 18:00 P1

Spectral properties of finite, laser-driven lattices of ultracold Rydberg atoms — •Wolfgang Zeller[2], Nikolas Tezak[1,2], Michael Mayle[3], and Peter Schmelcher[2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]JILA, NIST and University of Colorado, Boulder, Colorado 80309-0440, USA

We investigate the spectral properties of a finite lattice of coherently excited Rydberg atoms in the frozen Rydberg gas regime. Both uniform as well as multiply-spaced one-dimensional lattices are studied.

In the case of a weak laser coupling we give a comprehensive description for the excitation patterns and degeneracies. We find a multitude of Rydberg states with well-defined excitation properties which are adiabatically accessible starting from the ground state. The precise analysis and knowledge of the spectral features suggest a method to experimentally probe the strong and long-ranged mutual interaction of Rydberg atoms.

In the strong laser regime, the system can be approximated with analytical solutions by performing site-specific rotations and introducing fermionic ladder operators.

Patterned lattices allow us to design certain ground state crossovers involving different Rydberg excitation patterns.