Q 27: Ultra-cold atoms, ions and BEC III

Time: Wednesday 10:30–12:45 Location: BAR 106

Invited Talk Q 27.1 Wed 10:30 BAR 106

Ultracold chemistry and dipolar collisions in a quantum gas of polar molecules — •Silke Ospelkaus[1,2], Amodsen Chotia[2], Marcio de Miranda[2], Brian Neyenhuis[2], Kang-Kuen Ni[2], Dajun Wang[2], Jun Ye[2], and Deborah Jin[2] — [1]Institut fuer Quantenoptik und QUEST, Universitaet Hannover — [2]JILA, NIST and University of Colorado, Boulder, CO, USA

Ultracold polar molecular quantum gases promise to open new research directions ranging from the study of ultra-cold chemistry, precision measurements to novel quantum phase transitions. Based on the preparation of high-phase space density gases of polar KRb molecules [1,2,3], I will discuss the control of dipolar collisions and chemical reactions of polar molecules in a regime where quantum statistics, single scattering partial waves, and quantum threshold laws play a dominant role [4]. In particular, I will point out the crucial role of electric dipole-dipole interactions [5] and external confinement [6] in determining the chemical reaction rate. Finally, I will discuss prospects of reaching quantum degeneracy in bi-alkali samples of polar molecules and prospects for these systems as novel dipolar quantum many-body systems. [1] K. K. Ni, S. Ospelkaus, M. H. G. de Miranda, et al., Science 322, 231 (2008). [2] S. Ospelkaus, K. K. Ni, M. H. G. de Miranda, et al., Faraday Discussions 142, 351 (2009). [3] S. Ospelkaus, K. K. Ni, G. Quemener, et al., Phys. Rev. Lett. 104, 030402 (2010). [4] S. Ospelkaus, K. K. Ni, D. Wang, et al., Science 327, 853 (2010). [5] K. K. Ni, S. Ospelkaus, D. Wang, et al., Nature 464, 1324 (2010). [6] M. H. G. de Miranda, A. Chotia, B. Neyenhuis et al, arXiv: 1010.3731 (2010).

Q 27.2 Wed 11:00 BAR 106

Finite temperature interactions between cold atoms and nanostructures — Johannes Märkle, Benjamin Jetter, Philipp Schneeweiss, Michael Gierling, Gabriela Visanescu, Peter Federsel, Dieter Kern, Andreas Günther, József Fortagh, and •Thomas Judd — CQ Center for Collective Quantum Phenomena and their Applications, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

There is currently much interest in combining cold atoms with nanofabricated devices such as carbon nanotubes. Such research studies the interface between quantum gases and solid devices, and the interface between quantum and classical physics. It also provides insight into nanomachines, nanoelectronics, and macromolecular control. In such systems the role of temperature is important and related to quantum coherence properties.

Here we study quantum reflection and inelastic scattering of atoms from carbon nanotubes and show how cold atom experiments can extract information about nanostructures' van der Waals potentials. We also develop a novel finite temperature theory for cold atoms and study how solid structures may be used to cool and create coherence in quantum gases. We also explore the reverse case in which a cold atom cloud is used to cool solid objects.

Q 27.3 Wed 11:15 BAR 106

Dark solitons near the Mott-insulator–superfluid phase transition — •Konstantin Krutitsky[1], Jonas Larson[2,3], and Maciej Lewenstein[4,5] — [1]Fakultät für Physik der Universität Duisburg-Essen, Campus Duisburg, Lotharstraße 1, 47048 Duisburg, Germany — [2]NORDITA, 106 91 Stockholm, Sweden — [3]Department of Physics, Stockholm University, AlbaNova University Center, 106 91 Stockholm, Sweden — [4]ICFO-Institut de Ciències de Fotòniques, 008860 Castelldefels (Barcelona), Spain — [5]ICREA-Institució Catalana de Recerca i Estudis Avançats, Lluís Companys 23, 08010 Barcelona, Spain

Dark solitons of ultracold bosons in the vicinity of the Mott-insulator–superfluid phase transition are studied. Making use of the Gutzwiller ansatz we have found antisymmetric eigenstates corresponding to standing solitons, as well as propagating solitons created by phase imprinting. Near the phase boundary, superfluidity has either a particle or a hole character depending on the system parameters, which greatly affects the characteristics of both types of solitons. Within the insulating Mott regions, soliton solutions are prohibited by lack of phase coherence between the lattice sites. Linear and modulational stability show that the soliton solutions are sensitive to small perturbations and, therefore, unstable. In general, their lifetimes differ for on-site and off-site modes. For the on-site modes, there are small areas between the Mott-insulator regions where the lifetime is very large, and in particular much larger than that for the off-site modes.

Q 27.4 Wed 11:30 BAR 106

Overview of laser cooling of relativistic C3+ ion beams at ESR — •Michael Bussmann[1], Franziska Kroll[1], Markus Löser[1], Matthias Siebold[1], Ulrich Schramm[1], Weiqiang Wen[1,2,6], Daniel F.A. Winters[2,3], Tobias Beck[4], Benjamin Rein[4], Thomas Walther[4], Gerhard Birkl[4], Wilfried Nörtershäuser[2,5], Thomas Kühl[2], Christian Novotny[2,5], Christophor Kozhuharov[2], Christopher Geppert[2,5], Markus Steck[2], Christina Dimopoulou[2], Fritz Nolden[2], Xinwen Ma[6], and Thomas Stöhlker[2,3] — [1]Forschungszentrum Dresden-Rossendorf — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [3]Universität Heidelberg — [4]Technische Universität Darmstadt — [5]Universität Mainz — [6]Institute for Modern Physics, Chinese Academy of Science

We present an overview of the setup for all-optical cooling and beam diagnostics for relativistic C3+ ion beams at the Experimental Storage Ring (ESR) at GSI. With new optical diagnostics it is foreseen to improve the measurement of the longitudinal momentum spread of the beam by at least an order of magnitude. The new optical diagnostics together with the new Schottky diagnosis and beam profile monitor available at ESR will allow to access the complete phase space evolution of the beam inside the storage ring. With new laser systems developed for cooling beams with an initially large energy spread it will be possible to replace the electron cooler that was used to reduce the initial momentum spread of the ion beam.

Q 27.5 Wed 11:45 BAR 106

Stability and elementary excitations of a dipolar Bose gas in a 1D optical lattice — •Mattia Jona - Lasinio[1], Luis Santos[1], Stefan Mueller[1,2], Juliette Billy[2], Emanuel Henn[2], Holger Kadau[2], Philipp Weinmann[2], David Peter[2], and Tilman Pfau[2] — [1]ITP, Institut für Theoretische Physik, Leibniz Universität Hannover — [2]5. Physikalisches Institut, Universität Stuttgart

We consider a system of ultracold dipolar bosons in a 3D harmonic potential plus a 1D optical lattice along the weakest trapping direction. We assume all dipoles to be aligned along the lattice direction. We investigate the stability of the system as a function of the lattice strength and we highlight the role played by the long range dipole-dipole interaction. By solving the Bogoliubov equations we also characterize the different types of instability emerging in the system. We compare our theoretical predictions with the stability of a Chromium (^{52}Cr) condensate, finding the experimental evidence of the dipole-dipole long range character.

Q 27.6 Wed 12:00 BAR 106

Stability of a Dipolar Quantum Gas in a 1D Optical Lattice — •Stefan Mueller[1,2], Juliette Billy[1], Emanuel Henn[1], Holger Kadau[1], Philipp Weinmann[1], David Peter[1], Mattia Jona Lasinio[2], Luis Santos[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart — [2]Cluster of Excellence QUEST, Institut für Theoretische Physik, Leibniz Universität Hannover

We present first measurements on the stability of a BEC of chromium atoms in a 1D optical lattice. In a shallow lattice the trap aspect ratio of the underlying optical dipole trap (ODT) potential determines the critical scattering length [1]. However, in a deep lattice the system can be considered as a stack of pancake shape BECs, which individually are expected to be much more stable. We investigate the range from 0 to approx. 100 recoil energies lattice depth, observing a continuous decrease in the critical scattering length from +13 to -20 Bohr radii. Theoretical studies support significant intersite coupling via the long range dipole-dipole interactions.

[1] T.Koch *et al.*: Nature Physics **4**, 218 (2008)

Q 27.7 Wed 12:15 BAR 106

Controlled Charge Transport in lattice confined Alkaline-Earth Gases — •Rick Mukherjee[1], Alexander Eisfeld[1], Igor Lesanovsky[2], and Thomas Pohl[1] — [1]Max Planck Institute for the

Physics of Complex Systems, Dresden, Germany — [2]School of Physics and Astronomy, The University of Nottingham, United Kingdom

We study the dynamics of an ion immersed in an optical lattice of ultracold atoms. Here, simultaneous trapping of atoms and ions is made possible though the use of alkaline-earth atoms. Focussing on Strontium, we present extensive calculations of the atomic structure of highly excited states, as well as of the properties of molecular ions composed of such two-electron atoms. Optical dressing to Rydberg states is shown to permit precise and detailed control of charge exchange between neighbouring lattice sites, thereby offering unique opportunities to steer coherent charge transport and implement, e.g. a range Holstein-Hubbard type Hamiltonians in optical lattices.

Q 27.8 Wed 12:30 BAR 106

Mixing and de-mixing of dressed condensates — •Eike Nicklas, Helmut Strobel, Christian Gross, Tilman Zibold, Jiri Tomkovic, and Markus K Oberthaler — Kirchhoff Institute for Physics, University of Heidelberg, Germany

Two component interacting Bose-Einstein condensates provide a versatile system for studying the dynamics of multicomponent quantum fluids. Here we report on a method for controlling the effective interactions that govern the miscibility of the system by dressing the two components with a linear coupling field. We experimentally investigate the demixing dynamics of a binary condensate consisting of two hyperfine states of Rubidium and compare the results with numerical simulations. A Feshbach resonance allows changing the miscibility parameter of the system. We observe suppression of demixing when the two components are dressed with a linear coupling and the effective miscibility can be controlled via the coupling strength. Furthermore, we find that a miscible system is destabilized when applying a driving field.