Q 18: Quantum gases: Mixtures, spinor gases, disorder effects

Time: Monday 16:30–18:15 Location: E 001

Q 18.1 Mon 16:30 E 001

Entangling two distinguishable matter-wave bright solitons via collisions — Bettina Gertjerenken[1], Thomas Billam[2], Caroline Blackley[3], Ruth Le Sueur[3], Lev Khaykovich[4], Simon Cornish[5], and •Christoph Weiss[5] — [1]Institut für Physik,Carl von Ossietzky Universität, D-26111 Oldenburg, Germany — [2]Jack Dodd Center for Quantum Technology, Department of Physics, University of Otago, Dunedin 9016, New Zealand — [3]Joint Quantum Centre (JQC) Durham–Newcastle, Department of Chemistry, Durham University, Durham DH1 3LE, United Kingdom — [4]Department of Physics, Bar-Ilan University, Ramat-Gan, 52900 Israel — [5]Joint Quantum Centre (JQC) Durham–Newcastle, Department of Physics, Durham University, Durham DH1 3LE, United Kingdom

We investigate numerically the collisions of two distinguishable quantum matter-wave bright solitons in a one-dimensional harmonic trap. We show that such collisions can be used to generate mesoscopic Bell states which can reliably be distinguished from statistical mixtures. Calculation of the relevant s-wave scattering lengths reveals that such states could potentially be realized in quantum-degenerate mixtures of ^{85}Rb and ^{133}Cs. In addition to fully quantum simulations for two distinguishable dimers, we use a mean-field description supplemented by a stochastic treatment of quantum fluctuations in the soliton's center of mass: We demonstrate the validity of this approach by comparison to an effective potential treatment of the quantum many-particle problem.

Q 18.2 Mon 16:45 E 001

Quantum depletion of Bose-Einstein condensates in random lattice potentials — •Christopher Gaul[1,2] and Cord A. Müller[3] — [1]GISC, Departamento de Física de Materiales, Universidad Complutense, E-28040 Madrid, Spain — [2]CEI Campus Moncloa, UCM-UPM, Madrid — [3]Centre for Quantum Technologies, National University of Singapore, Singapore 117543, Singapore

We develop an inhomogeneous Bogoliubov theory for bosons on a tight-binding lattice [1]. In the first step, this consists in determining the condensate deformation caused by a weak external disorder potential. Then, the momentum distribution of quantum fluctuations around the deformed ground state is obtained via weak-disorder perturbation theory, and finally the resulting quantum depletion is calculated. As in the continuous case [2], the depletion due to the external potential, or potential depletion for short, is a small correction to the homogeneous depletion, validating our inhomogeneous Bogoliubov theory. Scattering due to disorder is strongest when the energy shell touches the Brillouin zone (BZ) edges. In the continuous limit, i.e., far away from the edges of the BZ, we reproduce previous results [2].

[1] arXiv:1209.5446. [2] New J. Phys., **14**, 075025 (2012).

Q 18.3 Mon 17:00 E 001

Observation of interspecies ^{6}Li -^{133}Cs Feshbach resonances — •Rico Pires[1], Marc Repp[1], Juris Ulmanis[1], Robert Heck[1], Eva Kuhnle[1], Matthias Weidemüller[1], and Eberhard Tiemann[2] — [1]Physikalisches Institut, Ruprecht- Karls Universität Heidelberg, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Germany

We will present the measurement of 19 interspecies Feshbach resonances in an ultracold Bose-Fermi mixture of ^{6}Li and ^{133}Cs in the energetically lowest spin states [1]. The resonances are assigned to s- and p-wave molecular channels by a coupled-channels calculation, which precisely reproduces all observed resonances. The undressed Asymptotic Bound State Model does not yield the same level of accuracy. Several broad s-wave resonances provide prospects to create fermionic LiCs molecules with a large dipole moment via Feshbach association followed by stimulated Raman passage. With two 60 G broad resonances, this system is a promising candidate for the observation of a series of Efimov resonances, due to the small Efimov scaling factor of 4.88. As two of the s-wave resonances overlap with a zero crossing of the Cs scattering length, the mixture also offers prospects for the observations of polarons.

[1] M. Repp et al., accepted for publication in Phys. Rev. A (R) (2012)

Q 18.4 Mon 17:15 E 001

An ultracold mixture of metastable helium and rubidium — Hari Prasad Mishra, Adonis Flores, Wim Vassen, and •Steven Knoop — LaserLaB, Department of Physics and Astronomy, VU University Amsterdam, The Netherlands

We are setting up an experiment to produce an ultracold atomic mixture of metastable triplet He (^{3}He* or ^{4}He*) and ^{87}Rb. Our main motivation is the observation of heteronuclear Efimov trimers, where the large mass ratio results in a much reduced scaling factor between successive Efimov states, compared to the homonuclear case. Our strategy to reach an ultracold mixture starts with a two-species 3D-MOT, loaded from a Zeeman slower (He*) and a 2D-MOT (Rb). Afterwards the mixture is transferred to a quadrupole magnetic trap (QMT) and a 1557-nm optical dipole trap for forced evaporative cooling of Rb and sympathetic cooling of He*. Recently we have realized the two-species 3D-MOT, in which we load 10^7 ^{4}He* and 10^9 ^{87}Rb atoms in a few seconds. After optical molasses and spin polarizing Rb, we transfer the ultracold mixture into the QMT. For the doubly spin-polarized mixture (^{4}He*: m_J=+1, ^{87}Rb: F=2, m_F=+2), Penning ionization is suppressed because of spin conservation [1]. First experiments will concentrate on Penning ionization, sympathetic cooling and Majorana loss of the ultracold mixture trapped in the QMT.

[1] L. J. Byron, R. G. Dall, Wu Rugway, A. G. Truscott, New. J. Phys. 12, 013004 (2010)

Q 18.5 Mon 17:30 E 001

Detection of Fisher information for mesoscopic quantum states — •Helmut Strobel[1], Wolfgang Muessel[1], Tilman Zibold[1], Luca Pezze[2], Eike Nicklas[1], Jiri Tomkovic[1], Ion Stroescu[1], Maxime Joos[1], Daniel Linnemann[1], David B. Hume[1], Augusto Smerzi[2], and Markus K. Oberthaler[1] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany — [2]INO-CNR and LENS, Largo Fermi 6, I-50125 Firenze, Italy

A very general classification of quantum states is the quantum Fisher information. It can be calculated from the density matrix which is experimentally accessible by state tomography. For a mesoscopic number of particles full state tomography with the necessary precision cannot be implemented in our system. Instead, we use the fact that the Fisher information is the key parameter quantifying possible sensitivity beyond the standard quantum limit in a phase estimation protocol.

We will present the realization of collective states of binary Bose-Einstein condensates with about 350 atoms and the analysis of their interferometric performance which gives a lower bound on the Fisher information. Our method is able to show that the Fisher information surpasses the shot-noise limit in a regime where no spin squeezing is present and thus reveals multiparticle entanglement.

Q 18.6 Mon 17:45 E 001

Mesoscopic dynamics of ultracold atoms in random potentials — •Cord A. Müller — Centre for Quantum Technologies, National University of Singapore, 117543 Singapore

I will briefly review the nonequilibrium dynamics of ultracold matter waves in random potentials, which attracts currently vivid experimental and theoretical interest. The recent observation of coherent backscattering of cold atoms [1], precisely following the theoretical prediction [2], presently opens avenues for a more refined understanding of disorder-induced localisation dynamics, both in weak and strong disorder. After an initial phase of momentum isotropisation [3], a coherent Cooperon peak persists in the momentum distribution, and turns into a remarkable twin-peak signal at the onset of Anderson localisation [4], whose precise properties remain to be studied.

[1] F. Jendrzejewski et al., Phys. Rev. Lett. **109**, 195302 (2012)
[2] N. Cherroret et al., Phys. Rev. A **85**, 011604(R) (2012)
[3] T. Plisson, T. Bourdel, C.A. Müller, arXiv:1209.1477
[4] T. Karpiuk et al., Phys. Rev. Lett. **109**, 190601 (2012)

Q 18.7 Mon 18:00 E 001

polar bosons in 1D disordered optical lattices — •Xiaolong Deng[1], Roberta Citro[2], Edmond Orignac[3], Anna Minguzzi[4], and Luis Santos[1] — [1]ITP, Universitaet Hannover, Germany — [2]Department of Physics, University Salerno, Italy — [3]LPMMC, CNRS, Grenoble, France — [4]ENS, Lyon, France

The effects of disorder and quasi-disorder on the ground-state properties of ultra-cold polar bosons in optical lattices are very interesting. In this talk, we show the rich phase diagrams from the interplay between (quasi-)disorder and inter-site interactions. A uniform disorder leads to a Haldane-insulator phase with finite parity order, whereas the density-wave phase becomes a Bose-glass at very weak disorder. For quasi-disorder, the Haldane insulator connects with a gapped generalized incommesurate density wave without an intermediate critical region. In addition, a novel kind of topological phase in the model will be discussed.