Q 20: Ultra Cold Atoms, Ions and BEC I (with A)

Time: Tuesday 14:00–16:00 Location: F 303

Invited Talk Q 20.1 Tu 14:00 F 303

Probing weakly bound molecules with nonresonant light — •Mikhail Lemeshko and Bretislav Friedrich — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, D-14195 Berlin, Germany

We show that weakly-bound molecules, such as those created via Feshbach resonances or photoassociation of ultracold atoms, can be accurately probed by "shaking" in a pulsed nonresonant laser field. The technique relies on the ability to impart a tunable value of angular momentum to the weakly bound molecule such that the centrifugal term concomitant with it expels the molecule's vibrational level from the potential and thus causes the molecule to dissociate. The laser intensity needed to impart a preordained value of the angular momentum varies characteristically with the internuclear distance. It is this characteristic dependence that can be used to map out the probability density of the vibrational state from which the molecule was forced to dissociate. A highly accurate long-range molecular potential can then be retrieved by inverting the vibrational probability density. This route to an accurate potential, independent of spectroscopy or scattering, complements what can be learned from either. We illustrate the technique's machinery by examining Feshbach molecules of acute interest, Rb2 and KRb. In addition, we discuss the possibilities to control the molecular size, the positions of Feshbach resonances, and the photoassociation probability using cw laser fields, and note that the laser field of an optical dipole trap may dissociate some of the most weakly bound molecules via the "shaking" mechanism.

Q 20.2 Tu 14:30 F 303

Bragg Spectroscopy of Ultracold Bosons in an Optical Lattice — •Ulf Bissbort, Yongqiang Li, and Walter Hofstetter — Institut für Theoretische Physik, Goethe Universität Frankfurt

In recent experiments [1,2] it has become possible to probe an interacting atomic gas of ultracold atoms in an optical lattice using Bragg spectroscopy, allowing energy and momentum to be resolved independently within the same measurement. We simulate these experiments under realistic conditions using the time-dependent bosonic Gutzwiller method, which, in contrast to Gross-Pitaevskii theory, captures depletion effects and becomes exact in both the non-interacting and strongly interacting limit. Furthermore, in contrast to static mean-field theory, it is capable of describing correlated excitations, such as Goldstone modes, and is numerically efficient, allowing simulations for all experimentally feasible time scales. In the limit of weak interactions Bogoliubov theory (including trap effects) is recovered, whereas in the case of strong interactions close to the Mott insulating border, a gapped amplitude mode is found to dominate, which has not yet been observed in experiments.

[1] P. Ernst et al., arXiv:0908.4242 (2009).
[2] D. Clément et al., Phys. Rev. Lett. **102**, 155301 (2009).

Q 20.3 Tu 14:45 F 303

Lattice-Ramp Induced Dynamics in an Interacting Bose-Bose Mixture at Zero and Finite Temperature — •Julia Wernsdorfer[1], Michiel Snoek[2], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik , Goethe-Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Deutschland — [2]Instituut voor Theoretische Fysica, Universiteit van Amsterdam, 1018 XE Amsterdam, Netherlands

In this work we model recent experiments [1] on an interacting 87Rb-41K bosonic gas in an optical lattice at zero and finite temperature. In particular we investigate the dynamics induced by the lattice-ramp up, which is an unavoidable step in the experimental procedure. Using the Gutzwiller mean-field method we examine whether the induced dynamics brings the system out of thermal equilibirum. We explain the experimentally observed oscillations in the visibility by relating them to the issue of adiabaticity [2].

[1] J. Catani, L. De Sarlo, G. Barontini, F. Minardi, and M. Inguscio, *Degenerate Bose-Bose mixture in a three-dimensional optical lattice*, Phys. Rev. A **77**, 011603 (R) (2008)
[2] J. Wernsdorfer, M. Snoek, and W. Hofstetter, *Lattice-Ramp Induced Dynamics in an Interacting Bose-Bose Mixture*, arXiv:0911.0697v1 (2009)

Q 20.4 Tu 15:00 F 303

Injection Locking of a Trapped Ion Phonon Laser — •Valentin Batteiger[1], Sebastian Knünz[1], Maximilian Herrmann[1], Guido Saathoff[1], Theodor W. Hänsch[1], Thomas Udem[1], and Kerry Vahala[2] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]California Institute of Technology, Pasadena, CA, USA

A single trapped ion is addressed by two laser beams, one tuned below, one above an atomic resonance. This opto-mechanical system can perform stable self-sustained oscillations, which we describe in close analogy to optical lasers [1]. We show the basic operation principle and present injection locking of the ion's motion to an externally controlled signal. Reference: [1] K. Vahala et al., Nature Physics 5, 682 (2009).

Q 20.5 Tu 15:15 F 303

Correlation versus commensurability effects for finite bosonic systems in one-dimensional lattices — •Ioannis Brouzos — Zentrum fuer Optische Quantentechnologien, Luruper Chaussee 149, 22761 Hamburg, Germany

We investigate few-boson systems in finite one-dimensional multi-well traps covering the full interaction crossover from uncorrelated to fermionised particles. Our treatment of the ground state properties is based on a numerically exact multi-configurational time-dependent method. For commensurate filling we trace the fingerprints of localisation, as the interaction strength increases, in several observables like local and non-local densities, fluctuations and momentum distribution. In addition for filling factor larger than one we observe on-site repulsion effects and other features of the physics beyond the Bose-Hubbard model regime approaching the Tonks-Girardau limit. The presence of an incommensurate fraction of particles induces partial delocalisation and spatial modulations of the profiles, taking into account the finite size of the system.

Q 20.6 Tu 15:30 F 303

Cooling into the spin-nematic state for a spin-1 Bose gas in an optical lattice — •Ming-Chiang Chung — National Center for Theoretical Sciences, Hsinchu, Taiwan

The possibility of adiabatically cooling a spin-1 polar Bose gas to a spin-nematic phase is theoretically discussed. The relation between the order parameter of the final spin-nematic phase and the starting temperature of the spinor Bose gas is obtained both using the mean-field approach for high temperature and spin-wave approach for low temperature. We find that there exists a good possibility to reach the spin-nematic ordering starting with spinor antiferromagnetic Bose gases.

Q 20.7 Tu 15:45 F 303

The Efimov effect in heteronuclear systems — •Kerstin Helfrich and Hans-Werner Hammer — Helmholtz-Institut für Strahlen- und Kernphysik and Bethe Center for Theoretical Physics, Universität Bonn, 53115 Bonn, Germany

Ultracold quantum gases with large scattering length show resonant enhancement of three-body loss rates when an Efimov trimer is at the scattering threshold. We calculate the three-body loss rates in heteronuclear mixtures of atoms for the case of large scattering length between the unlike atoms. Using zero-range interactions, we present results from the numerical solution of the integral equations for the recombination amplitude in momentum space and extract expressions for the recombination rate constants. Moreover, we calculate the relative positions of loss features for different sign of the scattering length and a first comparison with available experimental data is shown.