A 31: Ultracold Atoms: Trapping and Cooling I (with Q)

Time: Thursday 11:00–12:30 Location: P/H2

Group Report A 31.1 Thu 11:00 P/H2

Isospaced ion crystals and fault-tolerant Hahn-Ramsey interferometry — •Michael Johanning[1], Timm F. Gloger[1], Peter Kaufmann[1], Delia Kaufmann[1], Thomas Collath[1], M. Tanveer Baig[1], Nikolay V. Vitanov[2], and Christof Wunderlich[1] — [1]Faculty of Science and Technology, Department of Physics, University of Siegen, Walter Flex Str. 3, 57072 Siegen, Germany — [2]Department of Physics, St Kliment Ohridski University of Sofia, 5 James Bourchier blvd, 1164 Sofia, Bulgaria

We describe the static and dynamic properties of strings of ions stored in segmented electrodynamical Paul traps with a uniform ion separation achieved by an anharmonic effective potential generated by suitable voltages applied to segmented dc electrodes or by appropriate electrode shaping. We find expressions for the desired potential and calculate normal modes and the effective spin coupling when the ion string is exposed to a magnetic gradient. The effect on the radial confinement and the transition of the equidistant linear chain to an almost equidistant zigzag are investigated.

In the second part, a scheme for efficient correction of driving field frequency drifts in Ramsey interferometry is presented. The two near-resonant $\pi/2$ pulses of duration T used in the traditional Ramsey setup are supplemented with an additional refocussing pulse of duration $2T$ and opposite detuning. We demonstrate the validity of the concept by comparing experimental results from plain Ramsey and Hahn-Ramsey measurements, obtained from microwave spectroscopy on $^{171}Yb^+$ ions in a segmented linear Paul trap.

A 31.2 Thu 11:30 P/H2

"Second-order magic" radio-frequency dressing for magnetically trapped 87Rb atoms. — •Georgy Kazakov and Thorsten Schumm — Institute of Atomic and Subatomic Physics, Vienna University of Technology, Stadionallee 2, 1020 Vienna, Austria

We consider the modification of magnetic trap potential what allow to decrease the position-dependent decoherence in trapped atomic ensembles. To mitigate the perturbing effects of the magnetic trap, "near-magic field" configurations are usually employed, where the involved clock transition becomes independent of the atoms potential energy to first order. Still, higher order effects are a dominating source for dephasing, limiting the perfomance of this approach.

Here we propose a simple method to cancel the energy dependence to both, first and second order, using weak radio-frequency dressing. We give corresponding values of dressing frequencies, amplitudes, and trapping fields for 87Rb atoms, and investigate quantitatively the robustness of these "second-order magic" conditions to variations of the trapping field and dressing field amplitude and polarization. We conclude that such radio-frequency dressing can suppress field-induced dephasing by at least one order of magnitude in comparison with "ordinary" magic trap without dressing.

A 31.3 Thu 11:45 P/H2

Prethermalization of atoms due to photon-mediated long-range interactions — •Stefan Schütz and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany

Atoms can spontaneously form spatially ordered structures in optical resonators when they are transversally driven by lasers. This occurs when the laser intensity exceeds a threshold value and results from the mechanical forces on the atoms associated with superradiant scattering into the cavity mode. We treat the atomic motion semiclassically [1] and show that, while the onset of spatial ordering depends on the intracavity-photon number, the stationary momentum distribution is a Gaussian function whose width is determined by the rate of photon losses. Above threshold, the dynamics is characterized by two time scales: after a violent relaxation, the system slowly reaches the stationary state over time scales exceeding the cavity lifetime by several orders of magnitude. In this transient regime the atomic momenta form non-Gaussian metastable distributions, which emerge from the interplay between the long-range dispersive and dissipative mechanical forces of light [2]. We argue that the dynamics of self-organization of atoms in cavities offers a test bed for studying the statistical mechanics of long-range interacting systems.

[1] S. Schütz, H. Habibian, and G. Morigi, Phys. Rev. A **88**, 033427 (2013)

[2] S. Schütz and G. Morigi, Phys. Rev. Lett. **113**, 203002 (2014)

A 31.4 Thu 12:00 P/H2

Mean-Field Analysis of Selforganization of Atoms in Cavities — •Simon Jäger, Stefan Schütz, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany

Atoms can spontaneously form spatially ordered structures in optical resonators when they are transversally driven by lasers. This occurs by means of photon-mediated long-range forces, which establish correlations when the intracavity photon number exceeds a threshold value. The selforganization transition is an out-of-equilibrium phenomenon, where losses are an essential element determining the threshold behaviour [1]. In this contribution, we analyse the nature of the transition by means of a mean-field Fokker-Planck equation (FPE), which has been systematically derived from the master equation of atoms and cavity field and describes the dynamics of the one-particle density matrix. This FPE has the form of a Vlaslov equation when retardation effects, giving rise to noise, are neglected [2]. We analyse the dynamics of the order parameter, which quantifies the localization of the atoms in ordered patterns, and show that close to the selforganization threshold its dynamics is determined by a potential of Landau form in an appropriately defined thermodynamic limit. We then perform a stability analysis which permits us to identify the spectral properties of the intracavity field.

[1] S.Schütz and G. Morigi, Phys. Rev. Lett. **113**, 203002 (2014)

[2] A. Campa, T. Dauxois, and S. Ruffo, Phys. Rep. **480**, 57 (2009)

A 31.5 Thu 12:15 P/H2

Redistributional laser cooling and thermalization in dense gaseous ensembles — •Benedikt Gerwers, Stavros Christopoulos, Roberto Cota, Katharina Knicker, Anne Sass, Lars Weller, Peter Moroshkin, and Martin Weitz — Institut für Angewandte Physik der Universität Bonn, Deutschland

Redistributional laser cooling is a novel cooling technique applicable to ultradense gaseous ensembles. Optically active atoms undergo frequent collisions with noble buffer gas at high pressure, thus shifting the atomic resonances. This enables the absorption of far red-detuned laser excitation, while subsequent spontaneous decay occurs closer to the unperturbed resonances. During such a cooling cycle, kinetic energy of the order of kT is extracted from the ensemble. Thermal deflection spectroscopy indicates temperature changes as high as 500K. Temperature determination is also possible through Kennard-Stepanov analysis of the pressure-broadened absorption and fluorescence spectra of thermalized atomic and molecular transitions. Alkali and noble dimers are also investigated for molecular redistribution cooling.