A 11 Ultrakalte Atomphysik III

Zeit: Mittwoch 10:40–12:25 Raum: H6

A 11.1 Mi 10:40 H6

Atomic fountain clocks: recent results — •P. Rosenbusch[1], S. Bize[1], F. Chapelet[1], Ph. Laurent[1], H. Marion[1], C. Vian[1], Ch. Salomon[2], and A. Clairon[1] — [1]SYRTE, Observatoire de Paris, FRANCE — [2]LKB, ENS, Paris, FRANCE

In 1967 the second was defined through the hyperfine transition of ^{133}Cs. Since then much effort has been spend on realising a macroscopic, usable clock signal. The best approach today are atomic fountain clocks, regularly serving as primary standards. About 10^9 atoms are laser cooled to 1μK and launched up vertically. On their way up and down the atoms pass through a microwave cavity, where they interact with a reference microwave signal for about 12 ms. The duration between the two interactions is typically 0.5 s. This Ramsey interrogation leads to a 1 Hz FWHM of the central fringe [1].

In this conference we will present recent improvements on the 3 fountains operated by SYRTE and discuss their clock performances. We will demonstrate a relative clock stability of near to $1 \cdot 10^{-14}$ at 1 s and an accuracy of a few 10^{-16}. We give details on the first direct comparison between two fountain clocks having a stability of $6 \cdot 10^{-14}$ at 1 s [2]. Clock comparisons between Cs and Rb test the possible variation of fundamentals constants such as α. We find no variation of α above $7 \cdot 10^{-17}$/year [1,3].

[1] S. Bize *et al.*, C. R. Physique **5**, 829 (2004); S. Bize *et al.*, J. Phys. B: At. Mol. Opt. Phys. **38**, S449 (2005)
[2] C. Vian *et al.*, IEEE Trans. Instrum. Meas. **54**, 833 (2005)
[3] H. Marion *et al.*, Phys. Rev. Lett. **90**, 150801 (2003)

A 11.2 Mi 10:55 H6

Precision spectroscopy with entangled states — •Michael Chwalla, Christian Roos, Dany Chek-al-kar, Mark Riebe, Jan Benhelm, Kihwan Kim, Piet Schmidt, Wolfgang Hänsel, Hartmut Häffner, Timo Körber und Rainer Blatt — Institut für Experimentalphysik, Universität Innsbruck, Technikerstrasse 25, A-6020 Innsbruck

The use of entangled states can provide an increased sensitivity in quantum-limited spectroscopic measurements, leading to an uncertainty that is inversely proportional to the number of particles instead of the usual square-law dependence.

In this contribution, we show that spectroscopy with maximally entangled states of atoms also offers significant advantages over experiments done with single atoms. As a first example, we demonstrate that entanglement of two $^{40}Ca^+$ ions can be used for measuring tiny frequency shifts of the $S_{1/2} \rightarrow D_{5/2}$ transition arising from second-order Zeeman effect and electric quadrupole shifts due to the trapping potential. Secondly, we discuss how entanglement can be used to effectively eliminate first-order Zeeman shifts in spectroscopy with $^{40}Ca^+$ even though there are no $m = 0 \rightarrow m = 0$ transitions.

A 11.3 Mi 11:10 H6

Hydrodynamic shape oscillations in non-degenerate Bose gases — •Christian Buggle[1,2], Paolo Pedri[3], Wolf von Klitzing[1,4], and Johannes T.M. Walraven[1] — [1]FOM-Institute for Atomic and Molecular Physics, Kruislaan 407, 1098SJ Amsterdam and Van der Waals-Zeeman Institute, University of Amsterdam, Valckenierstraat 65-67, 1018XE Amsterdam, The Netherlands — [2]Ecole Normale Supérieure, 24, rue Lhomond, 75231 Paris, France — [3]Institut für Theoretische Physik III Universität Stuttgart, Pfaffenwaldring 57 V, 70550 Stuttgart, Germany and LPTMS Université Paris-Sud, bâtiment 100, Centre Scientifique d'Orsay, 91405 Orsay, France — [4]IESL-FORTH, P.O. Box 1527, 711 10 Heraklion, Greece

We have investigated collective oscillations of non-degenerate clouds of ^{87}Rb atoms as a function of density in an elongated magnetic trap. For the low-lying $M=0$ monopole-quadrupole shape oscillation we have measured the oscillation frequencies and damping rates. At the highest densities the mean-free-path is smaller than the axial dimension of the sample, which corresponds to collisionally hydrodynamic conditions. This allows us to cover the cross-over from the collisionless to the hydrodynamic regime. We present our experimental results, which show good agreement with theory. We also demonstrate a detailed analysis of the influence of trap anharmonicities on the oscillations in relation to observed temperature dependencies of the dipole and quadrupole oscillation frequencies. We present convenient expressions to quantify these effects.

A 11.4 Mi 11:25 H6

Quantum reflection traps — •Javier Madronero, Alexander Jurisch, and Harald Friedrich — Physik Department, Technische Universität München, 85747 Garching b. München

First estimates of survival times for atoms in a quantum reflection trap are based on simple one-dimensional sharp step potential models [1]. We investigate a more realistic description for higher-dimensional traps, in particular with regard to the atom-surface potential for nontrivial geometries.

[1] A. Jurisch and H. Friedrich, Phys. Lett. A (available online since 16 Sept. 2005).

A 11.5 Mi 11:40 H6

Cavity QED Detection of Interfering Matter Waves — •Tobias Donner, Thomas Bourdel, Stephan Ritter, Anton Öttl, Michael Köhl, and Tilman Esslinger — Institute of Quantum Electronics, ETH Zurich, CH-8093 Zurich, Switzerland

The duality between waves and particles is a fundamental concept of quantum mechanics. In a double-slit experiment with cold atoms we demonstrate the build-up of a matter wave interference pattern from single atom detection events.

The interference arises from two overlapping atom laser beams extracted from a Rubidium Bose-Einstein condensate. 36mm beneath the condensate, the atoms are detected in a high-finesse optical cavity. It works in the strong coupling regime of cavity quantum electrodynamics and is capable to identify single atom transits. The experiment reveals simultaneously the granular and the wave nature of matter.

A 11.6 Mi 11:55 H6

Laser Cooling of Barium — •Subhadeep De, Umakanth Dammalapati, Aran Mol, Klaus Jungmann, and Lorenz Willmann — KVI, Zernikelaan 25, 9747AA Groningen, The Netherlands

Laser cooled and trapped atoms are increasingly used worldwide for variety of high precision experiments. The TRIμP (Trapped Radioactive Isotopes: μicro-Laboratories for Fundamental Physics) at KVI is aimed to investigate new physics beyond the Standard Model by precision measurement of fundamental interactions and symmetries. Our approach is the search for permanent electric dipole moment (edm) in atom where radium (Ra) is a promising candidate. Its dipole moment is enhanced by orders of magnitude due to close lying states of opposite parity, i.e. 3P1 and 3D2 [1]. Radium is also interesting for measurements of atomic parity violation effects [2].

Since radium has a similar level structure to barium, we investigate as a first step laser cooling of barium. We slow down atoms from a thermal barium beam using 1S0-1P1 transition at 553.7 nm as a cooling cycle. Since the rather strong leakage into metastable D-states, the use of repumping lasers is essential (1130 nm and 1500 nm). We show that we increase the flux of atoms at low velocities relative to the Maxwell-Boltzmann distribution. We work on confining these slowed atoms in a MOT.

[1] V.V. Flambaum, Phys. Rev. A 60, R2611 (1999);V.A. Dzuba et al., Phys. Rev. A 61, 062509 (2000). [2] V.A. Dzuba et al., Phys. Rev. A 63, 062101 (2001).

A 11.7 Mi 12:10 H6

Zeitdauer von Transmission und Quantenreflexion in langreichweitigen attraktiven Potenzialen — •Eskender Mesfin und Harald Friedrich — Physik Department T30, T.U. München

In langreichweitigen attraktiven atomaren Potenzialen ist die Bewegung nicht nur bei sehr großen Abständen klassisch, sondern auch bei „kleineren“ Abständen, die allerdings noch einige dutzend atomare Einheiten betragen können. Dazwischen — für schwellennahe Energien bei einigen tausend atomaren Einheiten — liegt ein quantenmechanischer Bereich, an dem von fern einlaufende Teilchen auch ohne klassischen Umkehrpunkt reflektiert werden können. Die Wahrscheinlichkeiten für und der zeitliche Ablauf von solcher Quantenreflexion wurde für typische atomare Potenziale in den letzten Jahren untersucht [1–3].

Der gegenwärtige Beitrag widmet sich dem Zeitablauf der Transmission durch den quantenmechanischen Bereich im Potenzialschwanz. Die ermittelten Transmissionszeiten ergänzen stimmig die bekannten Resultate für Quantenreflexion der von fern einlaufenden Teilchen. Gleichzeitig erhalten wir aber auch Informationen über die Reflexionszeiten für Wellenpakete, die vom klassischen Bereich bei „kleineren" Abständen nach außen laufen und zurück reflektiert werden. Diese Quantenreflexionszeiten im Innenbereich scheinen naiven Kausalitätsüberlegungen zu widersprechen und bedürfen einer genaueren Interpretation.

[1] H. Friedrich, G. Jacoby, C.G. Meister, Phys. Rev. A 65 (2002) 032902
[2] H. Friedrich, A. Jurisch, Phys. Rev. Lett. 92 (2004) 103202
[3] A. Jurisch, H. Friedrich, Phys. Rev. A 70 (2004) 032711