A 33: Precision Spectroscopy of Atoms and Ions V (joint session A/Q)

Time: Friday 14:30–16:00 Location: B302

A 33.1 Fri 14:30 B302

Superconducting magnetic shielding for trapped ion qubits — •Elwin A. Dijck[1], Christian Warnecke[1,2], Claudia Volk[1], Stepan Kokh[1], Kostas Georgiou[1,3], Lakshmi P. Kozhiparambil Sajith[1,4,5], Christopher Mayo[1,3], Andrea Graf[1], José R. Crespo López-Urrutia[1], and Thomas Pfeifer[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg — [2]Heidelberg University — [3]University of Birmingham, United Kingdom — [4]DESY, Zeuthen — [5]Humboldt University of Berlin

Merging a linear Paul trap with a superconducting RF resonator produces a trapping environment with minimal magnetic field noise, ideal for precision spectroscopy and (highly charged) ion qubits. We characterize our ion trap of this type built from niobium [1] using microwave spectroscopy of Be^+ hyperfine qubits, determining the magnetic field stability and shielding factor. Due to flux trapping, the magnetic field applied during cooldown remains present in the ion trap and no external field needs to be applied during subsequent trap operation at cryogenic temperature. We find the trapped magnetic field to be stable over a period of months with relative changes at the 10^{-10} s^{-1} level. Additionally, magnetic field noise, which often limits qubit coherence, is passively shielded by the superconductor at all frequencies down to DC. Using Ramsey interferometry and spin echo measurements, we find coherence times of >100 ms without active field stabilization.

[1] J. Stark et al., Rev. Sci. Instrum. **92**, 083203 (2021)

A 33.2 Fri 14:45 B302

Progress toward direct frequency comb spectroscopy of ^{229m}Th — •Lars von der Wense[1], Chuankun Zhang[2], John F. Doyle[2], and Jun Ye[2] — [1]Max Planck Institute of Quantum Optics, Garching, Germany — [2]JILA, University of Colorado, Boulder, USA

Laser spectroscopy of the first excited nuclear state of ^{229}Th poses a long-standing challenge. Several groups worldwide are aiming for this goal, since success promises the development of a first nuclear optical clock of highest accuracy [1]. In this talk I will present the most recent progress of the efforts at JILA in Boulder, where direct frequency comb spectroscopy of ^{229m}Th is targeted [2]. For this purpose, a tunable VUV frequency comb has been developed [3] and new ^{229}Th targets were produced. Also, planned investigations within the new NuQuant project at MPQ will be addressed.

[1] L.v.d.Wense, B.Seiferle, Eur.Phys.J.A 56:277 (2020).
[2] L.v.d.Wense, C.Zhang, Eur.Phys.J.D 74:146 (2020).
[3] C. Zhang et al., Optics Letters 47, 5591 (2022).

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A 33.3 Fri 15:00 B302

BASE-STEP and the Permanent Magnet Trap — •Daniel Popper[1], Fatma Abbass[1], Hüseyin Yildiz[1], Markus Wiesinger[4], Christian Will[4], Björn-Benny Bauer[1,2], Jack Devlin[2,3], Stefan Erlewein[2,4], Julia Jäger[2,4,6], Barbara Latacz[2,3], Peter Micke[3,4], Elise Wursten[3], Gilbertas Umbrazunas[2,9], Klaus Blaum[4], Christian Ospelkaus[5,6], Wolfgang Quint[7], Jochen Walz[1,8], Stefan Ulmer[2,10], Christian Smorra[1], and Matthew Bohman[2,4] — [1]JGU Mainz, Germany — [2]Fundamental Symmetries Laboratory, RIKEN, Wako-shi, Japan — [3]CERN, Geneva, Switzerland — [4]MPI for Nuclear Physics, Heidelberg, Germany — [5]Leibniz Universität Hannover, Germany — [6]Physikalisch Technische Bundesanstalt, Braunschweig, Germany — [7]GSI, Darmstadt, Germany — [8]Helmholtz Intitute Mainz, Germany — [9]ETH Zürich, Switzerland — [10]Heinrich-Heine-Universität Düsseldorf, Germany

The ERC Project BASE-STEP is dedicated to the development of transportable antiproton traps to enhance the sensitivity of CPT invariance tests with antiprotons that are conducted in the BASE collaboration. For this, STEP uses a transportable superconducting magnet with a Penning trap system on a portable experiment frame. We have started commissioning the setup at CERN, and successfully tested our 90° defelctor at the end of 2022. In addition, we designed a permanent magnet set-up, consisting of two aubert- magnets that was conceived as an alternative to a superconducting magnet in the STEP concept that is more compact. Within the comissioning of the permanent magnet trap We succeeded in detecting He^+ ions in EBIT operation.

A 33.4 Fri 15:15 B302

Nuclear moments and isotope shifts of $^{249-253}$Cf probed by laser spectroscopy — •Dominik Studer for the Cf-Collaboration — Institut für Physik, JGU Mainz — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — Helmholtz-Institut Mainz

Obtaining a comprehensive picture of nuclear phenomena in heavy nuclei requires precise measurements of, e.g., spins, electromagnetic moments and charge radii. These provide important data to pin down shell closures and to reveal their effect on observables, and serve as benchmarks for theory. However, experiments at the heavy-element frontier are challenging due to of limited sample sizes or production yields, and scarcity of atomic structure information. In this contribution we report on high-resolution laser spectroscopy of $^{249-253}$Cf across the $N = 152$ shell closure. A sample containing $^{249-252}$Cf was produced in the HFIR reactor at Oak Ridge National Laboratory, USA. Part of this sample was later re-irradiated at the high-flux reactor at ILL to obtain ≈20 fg of ^{253}Cf. The spectroscopic measurements were carried out at the RISIKO mass separator in Mainz. Spectroscopy with the laser perpendicular to the atomic beam using the PI-LIST ion source proved to be feasible with sample sizes on the femtogram level. Isotope shifts and hyperfine structures were measured for three ground-state transitions with linewidths in the order of 100 MHz, allowing the determination of the nuclear magnetic dipole moments of ^{249}Cf, ^{251}Cf and ^{253}Cf. The spectroscopic measurements are presented and the results are compared to state-of-the-art theoretical calculations.

A 33.5 Fri 15:30 B302

Towards Coulomb coupling of a proton and a single $^9Be^+$ ion by using a microfabricated Penning trap — •Julia-Aileen Coenders[1], Jan Schaper[1], Juan Manuel Cornejo[1], Jacob Stupp[1], Amado Bautista-Salvador[2], Stefan Ulmer[3,4], and Christian Ospelkaus[1,2] — [1]Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [2]PTB, Bundesallee 100, 38116 Braunschweig, Germany — [3]Ulmer Fundamental Symmetries Laboratory, RIKEN, Wako, Saitama 351-0198, Japan — [4]HHU Düsseldorf, Universitässtraße 1, 40225 Düsseldorf, Germany

The BASE collaboration has allowed to measure the g-factor of single (anti-)protons stored in Penning traps with an unprecedented precision. At BASE Hannnover, we want to contribute to this goal by developing cooling and detection techniques based on the coupling of single (anti-)protons to single $^9Be^+$ ions that are laser cooled to their motional ground state.

For the planned coupling and sympathetic cooling of a proton with a laser cooled $^9Be^+$ ion, we need an asymmetric double well potential, due to the different masses of the particles. To generate this potential, a miniaturized trap geometry needs to be developed. Here we present the microfabrication steps that we applied to fused silica wafers to fabricate the cylindrical electrodes of our micro coupling Penning trap with an inner diameter of 0.8 mm and an axial length of 0.2 mm. In addition, we will show our latest results on adiabatic transport of single laser cooled $^9Be^+$ ions, as well as the current work on the coupling of two $^9Be^+$ ions in a macro coupling trap of 8 mm inner diameter.

A 33.6 Fri 15:45 B302

Accurate isotope shift measurements in the D1 and D2 lines of Sr^+ — •Julian Palmes, Phillip Imgram, Hendrik Bodnar, Kristian König, Patrick Müller, Imke Lopp, and Wilfried Nörtershäuser — Institut für Kernphysik, TU Darmstadt, Germany

Accurate measurements of different transition frequencies in multiple isotopes allow for the determination of the isotope shift and thus the calculation of the field shift ratio f, which is an important parameter to compare experimental results with state-of-the-art atomic structure calculations. After previous measurements of the corresponding lines in isotopes of the other alkaline-earth metals Ca^+ and Ba^+, absolute frequency measurements of the stable Sr^+ isotopes will be performed to be followed later by investigations of the $4d \rightarrow 5p$ transitions. Information on these transitions is required for an experiment on stable and short-lived Sr^+ ions in a Paul trap, currently being prepared at the KU Leuven. We report on measurements of the D1 and D2 transitions, using the quasi-simultaneous collinear/anticollinear laser spectroscopy (CLS). These were carried out with the Collinear Apparatus for Laser Spectroscopy and Applied Science (COALA) at the Technical University of Darmstadt. Additionally, this method allowed for a precise observation of the hyperfine splitting of the $^{87}Sr^{+}$ isotope. Funding by BMBF under contract 05P21RDFN1 is acknowledged.