A 44: Precision Spectroscopy of Atoms and Ions VI (joint session A/Q)

Time: Friday 14:30–15:30 Location: N 3

A 44.1 Fri 14:30 N 3

Towards a direct g-factor difference measurement of $^{12,14}C^{5+}$ — •Max Anton Gramberg[1], Matthew Bohman[1], Emily Burbach[2], Fabian Heisse[1], Philipp Justus[1], Kristian König[2], Jialin Liu[1], Wilfried Nörtershäuser[2], Sven Sturm[1], and Klaus Blaum[1] — [1]MPIK, Heidelberg — [2]IKP, TU Darmstadt, Darmstadt

ALPHATRAP [1] is a cryogenic Penning-trap apparatus for high-precision measurements. By confining single ions in ultra-stable electromagnetic fields, g-factor determinations at the sub-ppb level are enabled, offering stringent tests of quantum electrodynamics in extreme fields. Even higher precision was reached by measuring the direct g-factor difference of $^{20,22}Ne^{9+}$-ions co-trapped in a Penning trap [2]. In such coherent difference measurements otherwise unavoidable fluctuations of the magnetic field are largely suppressed, allowing to reach sub-ppt accuracy.

The planned measurement of the isotopic shift of the bound electron g-factor between $^{12}C^{5+}$ and $^{14}C^{5+}$ provides a unique opportunity for fundamental atomic physics. The lower nuclear charge Z enables an even more precise prediction by QED calculations and, when combined with the potentially improved precision in our recently upgraded apparatus, can be used to set competitive bounds on scalar dark matter candidates. Conversely, our planned measurement can also be used to extract an ultra precise charge radius difference and so benchmark other radius extraction methods as well as ab-initio nuclear theory.

[1] S. Sturm, *et al.* *Eur. Phys. J. Spec. Top.* **227**, 1425-1491 (2019). [2] T. Sailer, V. Debierre, *et al.* *Nature* **606**, 479-483 (2022).

A 44.2 Fri 14:45 N 3

Atomic Hydrogen beam formation and cryogenic pre-cooling for Project 8 — •Aya El Boustani and Sebastian Böser for the Project 8-Collaboration — Institute of Physics, Johannes Gutenberg University of Mainz, Germany

The Project 8 experiment aims to determine the absolute neutrino mass using Cyclotron Radiation Emission Spectroscopy (CRES) to measure radiation from tritium beta-decay electrons near the spectrum's endpoint, where the neutrino mass effect is most significant. Achieving sensitivity requires an atomic tritium source with well-characterized beam properties. At JGU Mainz, molecular hydrogen serves as a tritium analog and is dissociated in a tungsten capillary heated to 2200 K. The dissociated gas undergoes multi-stage cooling to 8 K, enabling atom trapping while minimizing recombination.

In this study, theoretical modeling and gas-flow simulations investigate the hot source and the first cooling stage. The tungsten capillary is modeled with axial temperature gradients, dissociation kinetics, and pressure profiles; the predicted flux and beam properties are benchmarked against Direct Simulation Monte Carlo results from the SPARTA code for low-density gas flows. In the pre-cooling stage, the atomic hydrogen beam passes through a bent, cold tube (Accommodator), whose geometry and gas*surface interaction parameters are studied with SPARTA to quantify beam capture, cooling, and recombination. These results guide the design and prototyping of an improved pre-cooling stage, being prepared for testing as part of a future atomic tritium source for Project 8.

A 44.3 Fri 15:00 N 3

Constraints on Ultra-Light Dark Matter from Networks of Optical Clocks and Cavities — •Luis Hellmich[1,2], Ullrich Schwanke[2], Cigdem Issever[1,2], and Steven Worm[1,2] — [1]Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany — [2]Humboldt-Universität zu Berlin, Berlin, Germany

Optical atomic clocks and cavities are high precision measurement devices, which are sensitive to variations of the fundamental constants. In this work, we are investigating the sensitivity of networks of optical clocks and cavities to variations of fundamental constants induced by ultra-light dark matter (ULDM). ULDM is expected to oscillate coherently on macroscopic length scales. We are exploring the possibility to detect such oscillations with a network of spatially separated frequency references in two complementary ways. On the one hand, the potential of an optical cavity network is studied. On the other hand, we are analyzing how daily and annual modulations of Earth's movement through the dark matter halo can be used to constrain ULDM models. The proposed setups could detect frequencies in the sub-Hz regime, making it possible to constrain dark matter masses $m \sim 10^{-10} - 10^{-14}$ eV. We present projected limits on the scalar coupling to Standard Model particles for a few benchmark scenarios and compare them to existing constraints from equivalence principle tests.

A 44.4 Fri 15:15 N 3

Electron Mass, Charge and Sommerfeld FSC — •Manfred Geilhaupt — HS Niederrhein Mönchengladbach

Einstein: Ich wüsste gern, was ein Elektron ist.

**e^2=2*alphah*c*eps0 (no energy!). Question: What must be known else, able to answer Einsteins question? Restmass & Charge must be derived from a principle theory. Results from GR+TD: restmass me(alpha,N) & charge e(alpha). expectation values, both depend on alpha. The r(t)-generating two differential equations - not like Schrödinger but source for mass and charge - can be found using a common Newton Einstein Equation of Motion:

**dP/dt=f1+f2+f3+f4+f5 coming up with 5 internal parts from partial derivation. The second part (f2= m*ddr/ddt) leads to restmass me(alpha,N) being an effective value from the solution m(t) if r(t) is a generating function same for all 5 parts. u(t) is a unit vector possible to rotate (du/dt). The first equation (f1=dr/dt*dm/dt) - if m(t) is known already from part two - leads to charge e(alpha) while alpha is the Sommerfeld FSC:

**alpha=(1/beta)*(1/beta)*1/g44*3/4(1+log(1/3))*(1+log(1/3)) - appears when using r(t) to get m(t) from equation f2. Beta is the Einstein SR parameter while g44 is the well known GR-metric number: while within (e/m)=..1/sqrt(N) here alpha cancels!

alpha represents the continuum part and N the quantum part of nature. So GR+TD predicts QM's quantisation phenomena physically - based on causality and TD principles applied.