HK 71: Structure and Dynamics of Nuclei XIII

Time: Thursday 16:00–17:30 Location: HK-H7

Group Report HK 71.1 Thu 16:00 HK-H7

Nucleon and nuclear structure from measurements in muonic and normal atoms — •Randolf Pohl — Johannes Gutenberg Universität Mainz

Laser spectroscopy of simple atoms is sensitive to properties of the atomic nucleus, such as its charge and magnetization distribution, or its polarizability. This allows determining the nuclear parameters from atomic spectroscopy, but also limits the attainable precision for the determination of fundamental constants or the test of QED and the Standard Model.

In light muonic atoms and ions, one negative muon replaces all atomic electrons, resulting in a calculable hydrogen-like system. Due to the muon's large mass (200 times the electron mass), the muon orbits the nucleus on a 200 times smaller Bohr radius, increasing the sensitivity of muonic atoms to nuclear properties by 200^3 = 10 million.

This has resulted in a 10fold increase in the precision of the charge radius of the proton, deuteron, and the stable helium nuclei. We're currently measuring the hyperfine structure in muonic hydrogen to obtain information about the magnetization of the proton. In Mainz, we're setting up an experiment to determine the triton charge radius by laser spectroscopy of atomic tritium.

HK 71.2 Thu 16:30 HK-H7

nuclear structure corrections in muonic atoms from chiral effective field theory — •simone salvatore li muli[1,2] and sonia bacca[1,2] — [1]Institut für Kernphysik, Johannes Gutenberg Universität, Mainz, Germany — [2]Helmholtz-Institut Mainz, Johannes Gutenberg Universität Mainz, Germany

Precision spectroscopic measurement in muonic atoms require precision theoretical calculations to be able to extract nuclear charge and magnetic radii. While quantum electrodynamics calculations are very precise, nuclear structure corrections are presently the largest source of uncertainty and consequently the bottle-neck for fully exploiting the experimental precision. Utilizing techniques and methods developed in few-body nuclear physics, we have been able to provide the so far most precise determination of nuclear structure corrections to the Lamb shift. I will present our recent calculations for light muonic atoms, where we use chiral effective field theory potentials and perform a study of the uncertainties induced by the order-by-order chiral expansion.

HK 71.3 Thu 16:45 HK-H7

Nuclear structure investigations on $^{253-255}$Es by laser resonance ionization spectroscopy — •Steven Nothhelfer for the Einsteinium-Collaboration — Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — Helmholtz-Institut Mainz, 55099 Mainz, Germany — GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany

Experimental data on the hyperfine structure splittings and isotope shifts of spectral lines in transuranium elements reveal valuable information about the structure of their atomic nuclei. In this poster we will present results of laser resonance ionization spectroscopy performed on the rare isotopes $^{253-255}$Es at the RISIKO mass separator in Mainz. With small sample sizes ranging down to fg, the prominent 351.5 nm ground-state transition ($5f^{11}7s^2 \rightarrow 5f^{11}7s7p$) was measured in all three Es isotopes. Furthermore, four additional ground-state transitions were measured in ^{254}Es. Hyperfine structure analysis resulted in spin values of $I(^{254}\mathrm{Es}) = 7$ and $I(^{255}\mathrm{Es}) = 7/2$. Nuclear magnetic dipole moments as well as spectroscopic electric quadrupole moments were derived from the extracted hyperfine coupling constants. The literature value of the nuclear magnetic dipole moment for ^{254}Es obtained from angular anisotropy measurements of ^{254}Es α-radiation [1] deviates from our more precise value of this quantity.

Further measurements are planned on ^{254}Es using a new high-resolution gas-jet apparatus [2]. Most recent results will be presented.

[1] N. Severijns et al., Phys. Rev. C 79 (2009), 064322. [2] S. Raeder et al., Nucl. Instrum. Methods. Phys. Res. B 463 (2020), 272-276.

HK 71.4 Thu 17:00 HK-H7

First results of an all-optical nuclear charge radius determination at COALA — •Phillip Imgram[1], Emily Burbach[1], Bernhard Maass[2], Patrick Müller[1], and Wilfried Nörtershäuser[1] — [1]Institut für Kernphysik, TU Darmstadt, Germany — [2]Argonne National Laboratory, Chicago, IL, USA

The Collinear Apparatus for Laser Spectroscopy and Applied Physics (COALA) at the Institute of Nuclear Physics of TU Darmstadt has been designed to perform high-precision experiments on stable isotopes for high-voltage measurements, atomic physics and nuclear structure research. The recently applied upgrade with an electron-beam ion source allows us to study transitions in multiply-charged ions. Here, the focus is on light ions to determine nuclear charge radii with an all-optical approach, i.e. without referencing to charge radii determined by elastic electron scattering or transitions in muonic atoms. Therefore, the $^3S_1 \rightarrow {}^3P_J$ transitions of He-like ions will be measured to a targeted accuracy of <1 MHz with simultaneous collinear and anticollinear laser spectroscopy. This experimental value can directly be compared with nonrelativistic QED calculations [1] that are currently being performed. This contribution will summarize the current status of the project and present first results of $^{12}C^{4+}$ measurements. This project is supported by DFG (Project-ID 279384907 - SFB 1245) and by BMBF (05P21RDFN1).

[1] V. Patkós, Phys. Rev. A 103, 042809 (2021)

HK 71.5 Thu 17:15 HK-H7

CREMA-Measuring the Ground State Hyperfine splitting of Muonic Hydrogen — •Siddharth Rajamohanan[1], Ahmed Ouf[1], and Randolf Pohl[2] — [1]Johannes gutenberg universität mainz, Mainz, Germany — [2]PRISMA+Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg-Universitat Mainz, 55099 Mainz, Germany

Precision measurements on atoms and ions provide a wealth of information of bound state QED and is a unique test of the Standard Model. Significant work has been done to understand the proton radius puzzle. To this end, the CREMA collaboration is presently pursuing a pulsed laser spectroscopy measurement of ground state HFS in muonic hydrogen upto 1ppm accuracy to understand the Zemach radius, which encodes the magnetic properties of the proton. A unique laser system, the multi-pass cavity and the scintillation detection system are necessary for the experiment. We report our progress on the same.