HK 21: Structure and Dynamics of Nuclei V

Time: Wednesday 13:45–15:45 Location: AM 00.011

Group Report HK 21.1 Wed 13:45 AM 00.011

Towards high-precision laser spectroscopy of trapped radioactive ions — •Phillip Imgram[1,2], Stefanos Pelonis[1], Tobias Christen[1], Julien Grondin[1], Angelos Karadimas[1], Arda Kayaalp[1], Sandro Kraemer[1], Agota Koszorus[1], Pierre Lassegues[1], Robbe Van Duyse[1], and Ruben de Groote[1] — [1]Department of Physics and Astronomy, Instituut voor Kern-en Stralingsfysica, KU Leuven, 3001, Leuven, Belgium — [2]Facility for Antiproton and Ion Research in Europe GmbH, Darmstadt, Germany

Benchmarking nuclear models through precise measurements of nuclear observables such as nuclear charge radii and electromagnetic moments in exotic, short-lived nuclei is crucial, and most precise and nuclear-model-independent results are achieved through laser spectroscopy. Here, well-established in-source or collinear laser spectroscopy techniques are usually limited in precision by either the temperature of the ions or the interaction time of the ions with the laser light. To overcome both limitations, a new offline beamline has been commissioned at KU Leuven to develop laser spectroscopy on trapped ions at radioactive ion beam (RIB) facilities [1]. This contribution will give an overview of the project and present the first results from our linear Paul trap, which includes the deceleration, trapping, and laser cooling of Sr^+ ions from a 10 keV beam energy to a few 10 mK in temperature and first laser spectroscopy measurements. Finally, an outlook on the upcoming developments in Leuven will be provided and prospects for implementation of this setup at RIB facilities will be explored. [1] P. Imgram et al., Rev. Sci. Instr. 96, 093302 (2025)

HK 21.2 Wed 14:15 AM 00.011

POSEIDON: A new setup for collinear laser spectroscopy at the N=126 factory — •Julian Palmes[1], Guy Savard[2], and Jason Clark[2] for the POSEIDON-Collaboration — [1]Institut für Kernphysik der Technischen Universität Darmstadt, Darmstadt, Germany — [2]Argonne National Laboratory, Lemont, USA

The nuclear charge radius is a fundamental nuclear observable and a sensitive probe of the forces and correlations that shape atomic nuclei. While for stable isotopes, absolute radii can be determined by muonic spectroscopy and electron scattering, the extraction of differential charge radii of exotic nuclei relies on optical isotope shift measurements. In the neutron-rich region near the N=126 shell closure, which is of special interest for astrophysical processes, our knowledge of those fundamental properties is sparse. These isotopes are difficult to produce due to limited cross-sections for conventional methods. Multi-nucleon transfer (MNT) reactions provide sufficiently large cross sections but have large momentum transfers, making beam collection challenging.

At the N=126 factory at the Argonne National Laboratory, a gas catcher directly after the target will collect these exotic nuclei and allow spectroscopy on MNT reaction products. We present POSEIDON, our newly designed collinear laser spectroscopy beamline and present plans to measure the charge radius of platinum isotopes across N=126.

This project is supported by the German Research Foundation (Project-ID 279384907 - SFB1245).

HK 21.3 Wed 14:30 AM 00.011

Precision mass measurement of n-deficient cadmium isotopes at ISOLTRAP — •Christoph Schweiger for the ISOLTRAP-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Isoltrap [1] is a multi-ion-trap mass spectrometer located at ISOLDE/CERN dedicated to high-precision mass measurements of artificially produced, short-lived, exotic radionuclides far from stability. Experimentally, Isoltrap employs multi-reflection time-of-flight and Penning-trap mass spectrometry techniques for direct mass measurements. Following the mass-energy equivalence, the measured masses can be related to nuclear binding energies, reflecting the underlying interactions and structure in the nucleus. Knowledge of the binding energies therefore allows the study of nuclear structure and nuclear astrophysics. To this end mass filters are employed. In addition, precision mass data have applications in fundamental physics such as neutrino or weak interaction studies.

Following an introduction of the experimental setup, recent mass measurements of neutron-deficient cadmium isotopes in vicinity of the self-conjugate doubly-magic ^{100}Sn will be presented. The contribution will also include technical developments that improved the experimental setup significantly.

[1] Lunney, D. et al., J. Phys. G: Nucl. Part. Phys. 44, 064008 (2017)

HK 21.4 Wed 14:45 AM 00.011

Progress towards Collinear Laser Spectroscopy of stable Phosphorus Atoms — •Imke Lopp, Kristian König, Daniela Tandara, and Wilfried Nörtershäuser — Institut für Kernphysik, Technische Universität Darmstadt

Phosphorus is of special interest for collinear laser spectroscopy, since it offers a proton-halo candidate, ^{26}P, at the proton dripline. By measuring isotope shifts, collinear laser spectroscopy provides access to changes in the nuclear charge radii along the isotopic chain, enabling a sensitive probe of halo structures. In the case of phosphorus, experimental challenges have prevented laser spectroscopy so far. There are no laser-accessible transitions from the ionic or atomic ground state. However, from meta-stable atomic states, transitions in the deep UV at 215 nm and 255 nm can be accessed with state-of-the-art laser systems. Therefore, a charge exchange cell is used to populate these states using in-flight charge exchange reactions. Preparation studies on stable ^{31}P are performed at the COALA setup at TU Darmstadt, where a new charge exchange cell and Penning Ionisation Gauge ion source are commissioned for this purpose. The status of the new charge exchange cell and ion source, as well as the progress towards collinear laser spectroscopy of stable phosphorus atoms will be presented.

This project is supported by BMFTR (05P24RD8) and the German Research Foundation (Project-ID: 279384907 - SFB 1245)

HK 21.5 Wed 15:00 AM 00.011

Laser Spectroscopy of neutron-rich and neutron-deficient Tm isotopes with RADRIS at GSI/HIM and RISIKO at JGU Mainz — •Jana Weyrich for the RADRIS-Collaboration — GSI, Darmstadt, DE — Helmholtz-Institut, Mainz, DE — Johannes Gutenberg-Universität, Mainz, DE

Nuclear shell effects stabilize the nuclei of heavy and superheavy elements against spontaneous fission, counteracting the Coulomb repulsion of the protons in the nucleus. Thus, studying physical properties in that region of the nuclear chart enhances our understanding of the nuclear structure. These elements, however, are radioactive, often short-lived, and generally produced only in limited quantities. As a result, the technique of **R**esonance **I**onization **S**pectroscopy (RIS) plays a crucial role in studying atomic spectra to determine atomic and nuclear properties, as it features high sensitivity, efficiency, and selectivity. As on-line studies of the rare species are time- and cost-intensive, it is advisable to investigate lighter atomic homologues in advance.

In this work, studies of ^{169}Tm and ^{170}Tm were performed with the RISIKO mass separator at JGU Mainz, Germany, to study the sensitivity of ionization schemes. Further on-line studies with the **RA**diation **D**etected **R**esonance **I**onization **S**pectroscopy (RADRIS) apparatus at GSI-FAIR in Darmstadt, Germany, included ^{152m}Tm, ^{153}Tm, and ^{154m}Tm. In this contribution, the results will be discussed, which include isotope shift measurements in three optical transitions and a first determination of the magnetic moment of ^{152m}Tm.

HK 21.6 Wed 15:15 AM 00.011

Investigating molecular formation and breakup towards measurements of the halo candidate ^{8}B — •Julien Spahn[1], Jason Clark[2], Bernhard Maass[2], Peter Müller[2], Wilfried Nörtershäuser[1], and Guy Savard[2] — [1]Institute for nuclear physics, TU Darmstadt, Germany — [2]Physics division, Argonne National Laboratory, USA

Since the first discovery of halo nuclei, neutron halos in particular have been characterized using nuclear reactions and laser spectroscopy. A measurement of the nuclear charge radius of the more exotic proton halo in the isotope ^{8}B, however, is still pending. An ongoing effort at Argonne's ATLAS facility aims to investigate ^{8}B via collinear laser spectroscopy. However, ^{8}B ions readily form molecules with residual contaminants in the He buffer gas of the gas catcher used to cool and extract the ions. These molecular species reduce the yield of the pure (bunched) ^{8}B beam. This contribution will focus on the commissioning of a new setup allowing investigation of the beam composition in continuous and bunched mode, relying on neural network based analysis of alpha decays detected via an MCP behind a velocity filter. Additionally, first results from online experiments investigating the molecular formation in the gas catcher and the breakup of the formed molecules in the RFQ will be presented.

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HK 21.7 Wed 15:30 AM 00.011

Production and Collinear Laser Spectroscopy of Helium-like Boron Ions — •Emily Burbach, Hendrik Bodnar, Finn Köhler, Kristian König, Imke Lopp, Wilfried Nörtershäuser, and Julien Spahn — Institut für Kernphysik, Technische Universität Darmstadt

Nuclear ground state properties of short-lived isotopes can be studied using collinear laser spectroscopy (CLS). Differential root-mean-square charge radii can be derived from isotope shifts of atomic transitions between different isotopes. For light systems, also the absolute charge radius can be determined by applying NRQED calculations and high-precision absolute frequency measurements. The Collinear Apparatus for Laser Spectroscopy and Applied Sciences (COALA) at TU Darmstadt is suitable for high-precision transition frequency measurements at the ppb-level that are required for light isotopes. There, highly charged boron ions were produced in an electron beam ion source. We present experimental details on the efficient production of helium-like boron ions in the metastable $^3S_1$ state, where laser-accessible atomic transitions occur at 283 nm and the subsequent laser spectroscopy measurements. The absolute charge radius of ^{11}B can be determined from the transition frequency and NRQED calculations, which was previously demonstrated for ^{12}C [1]. An overview of the current status of the analysis is given.

This project is supported by DFG (Project-ID 279384907 - SFB 1245).

[1] P. Imgram et al., Phys. Rev. Lett. **131**, 243001 (2023).