HK 59: Structure and Dynamics of Nuclei X

Time: Friday 11:00–13:00 Location: J-HS E

Group Report HK 59.1 Fri 11:00 J-HS E

The (18O, 16O) two-neutron transfer reaction as a gateway to study the low-spin structure of neutron-rich nuclei close to stability. — •Vasil Karayonchev, Jan Jolie, Arwin Esmaeilzadeh, Andrey Blazhev, Christoph Fransen, and Claus Müller-Gatermann — Institut für Kernphysik, Zülpicher Straße 77 50937 Köln, Deutschland

Successful feasibility studies of the (18O, 16O) two-neutron transfer reaction were performed with various targets, ranging from 50Ti to 204Pb, at the FN Tandem accelerator facility of the University of Cologne, opening new experimental possibilities to study neutron-rich nuclei close to stability. The reaction was used to obtain lifetimes of low-spin states in 90Sr and 98Zr using the Doppler shift attenuation method and the recoil distance Doppler shift technique, respectfully. The newly obtained lifetimes in 90Sr corroborate the effects of the subshell closure at Z=38 and also indicate the possible existence of a state of a mixed-symmetry character. The measured lifetimes in 98Zr suggest the coexistence of several shapes of different deformations which are weakly mixed.

HK 59.2 Fri 11:30 J-HS E

The (p,3p) reaction mechanism: a sequential process — •Axel Frotscher and Mario Gómez for the SEASTAR15-Collaboration — TU Darmstadt, Darmstadt, Deutschland

The knockout of nucleons from nuclei is a powerful tool to investigate nuclear structure. In particular, the knockout of nucleons at energies above 200 MeV/nucleon from a hydrogen target, so called quasi free scattering, is believed to be a clean probe for nuclear structure and have led to several recent experimental programs and theoretical developments. In this work, we are interested to reactions that lead to the removal of two nucleons. Indeed, it was observed in several occurrences that different final states in a nucleus are populated when produced from one nucleon knockout (p,2p) or from two nucleon knockout (p,3p). The understanding of the later could provide a new tool for nuclear spectroscopy.

The analysis of two experimental campaigns conducted at the RIBF in RIKEN, Japan, is presented here. The proton distribution from several neutron-rich medium-mass nuclei were analysed. The radioactive nuclei were impinging onto a 100-mm long liquid hydrogen target. The protons issued from the reaction were measured with the MINOS time-projection chamber surrounding the target, giving access for the first time to angular correlations of the three protons in the final state. The obtained proton distributions have been benchmarked against kinematical models assuming three different reaction mechanisms.

This work is supported by the DFG through grant no. SFB1245.

HK 59.3 Fri 11:45 J-HS E

Current Status of the PUMA Project — Jonas Fischer, Erik Friedrich, Yuki Kubota, Noritsugu Nakatsuka, Alexandre Obertelli, •Alexander Schmidt, and Frank Wienholtz for the PUMA-Collaboration — TU Darmstadt, Darmstadt, Germany

The antiProton Unstable Matter Annihilation (PUMA) project aims at the investigation of the outermost density tail for the protons and neutrons of short-lived nuclei by the use of low-energy antiprotons at CERN. A special focus will be set on medium mass neutron-rich nuclei, for which a thick neutron skin or a neutron halo has been predicted but a solid experimental proof is still missing. In order to quantify if a nucleus has a halo or a neutron skin, the surface of the nucleus will be investigated by the means of annihilations with antiprotons. In these annihilation processes the produced energy is mainly carried away by charged and neutral pions, whose sum of the charges is equal to the sum of charges of the antiproton and the annihilated nucleon, which will allow us to distinguish between neutron and proton annihilations. Based on detecting and identifying all produced charged pions, the measurements will determine the ratio of protons to neutrons on the surface of the nucleus.

This contribution will provide an overview of the current status of the PUMA project with a special focus on the proof-of-principle setup for the diagnostics and the trapping scheme. It is supported by the ERC-COG through grant no. 726276.

HK 59.4 Fri 12:00 J-HS E

Extreme high vacuum for the PUMA trap — •Erik Friedrich[1], José António Ferreira Somoza[2], Paolo Chiggiato[2], Audric Husson[1], Wojciech Kubinski[1], Noritsugu Nakatsuka[1], Alexandre Obertelli[1], and Frank Wienholtz[1] for the PUMA-Collaboration — [1]Technische Universität Darmstadt, Darmstadt, Germany — [2]CERN, Geneva, Switzerland

The antiProton Unstable Matter Annihilation (PUMA) project targets to study short-lived nuclei with antiprotons at CERN. The technical challenge of PUMA is to store approximately one billion antiprotons for at least a month and transport them from the ELENA low-energy antiproton ring to the ISOLDE radioactive-ion beam facility at CERN. For this long-term storage, an extremely high vacuum (XHV) of about 10^{-17} mbar, corresponding to a gas density about $20\,\mathrm{cm}^{-3}$, should be achieved by cryopumping. The residual gas density at XHV region depends on the molecular occupation of hydrogen on the cryogenic surface. The key parameter to simulate this process is so-called the hydrogen isotherms at XHV. The specificity of the PUMA experiment is that the cryopumped region should be open to the beam line for the introduction of low-energy (few keV) ions into the PUMA device. The presentation reports on the vacuum cryostat of PUMA and summaries the simulations with Molflow+ and COMSOL Multiphysics to optimize the cryostat design. In addition, the development of a cryogenic gate valve is described.

HK 59.5 Fri 12:15 J-HS E

Current status of COALA - Towards an all-optical nuclear charge radius determination — •Phillip Imgram[1], Zoran Andelkovic[2], Axel Buss[3], Volker M. Hannen[3], Kristian König[4], Jörg Krämer[1], Konstantin Mohr[1], Patrick Müller[1], Rodolfo Sánchez[2], and Wilfried Nörtershäuser[1] — [1]IKP, TU Darmstadt — [2]GSI, Darmstadt — [3]IKP, WWU Münster — [4]NSCL, MSU, East Lansing, MI, 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 planned upgrade with an electron-beam ion source will allow us to study transitions in multiply-charged ions. Here, the focus will be 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 $^3\mathrm{S}_1 \rightarrow {}^3\mathrm{P}_J$ transitions of He-like ions will be measured to an accuracy of <1 MHz with simultaneous collinear and anticollinear laser spectroscopy. This experimental value can directly be compared with nonrelativistic QED calculations (NRQED) [1] that are currently being performed. This contribution will summarize the current status of the project which is supported by BMBF (05P19PMFA1 and 05P19RDFAA) and by DFG (SFB 1245).

[1] V.A. Yerokhin et al., Phys. Rev. A 98, 032503 (2018)

HK 59.6 Fri 12:30 J-HS E

Compact Collinear Laser Spectroscopy Setup for Ion Source Development and Educational Research — •Philipp Bollinger, Tim Ratajczyk, Tim Lellinger, and Wilfried Nörtershäuser — Institut für Kernphysik, Technische Universität Darmstadt

Collinear laser spectroscopy (CLS) is widely used to perform highly precise measurements of atomic spectra to extract nuclear properties, namely charge radii, magnetic dipole and electric quadrupole moments [Neugart et al. J. Phys. G. 44 064002 (2017)]. It has also been used to test QED calculations with light as well as highly charged heavy ions, and was applied on relativistic beams to test special relativity. We are developing a compact setup for CLS to be used as hands-on experience in the Students Lab to familiarize them with the technique and its science applications. Moreover, the apparatus will serve for quick equipment tests and ion source specifications. For this setup a specially designed 90° bender with static electric fields is used to superimpose the ion beam with a collinear laser beam. A Faraday cup provides means to optimize the ion beam path and an optical detection region consisting of elliptic mirrors and photomultipliers are used for fluorescence detection. We will present details of the layout and the current status of the project together with some first measurements with the 90° bender.

We acknowledge funding from HIC for FAIR

HK 59.7 Fri 12:45 J-HS E

Status of a buffer gas cooled Low-Emittance Laser Ablation Ion Source with two RF funnels — •Tim Lellinger[1], Tim Ratajczyk[1], Philipp Bollinger[1], Victor Varentsov[2,3], and Wilfried Nörtershäuser[1] — [1]Institut für Kernphysik, TU Darmstadt — [2]Facility for Antiproton and Ion Research in Europe (FAIRGmbH), Darmstadt — [3]Institute for Theoretical and Experimental Physics, Moscow, Russia

Ion sources of low-emittance are of interest in many applications of experimental low-energy physics, for example as ion sources for collinear laser spectroscopy or ion trap experiments, or as ion sources for accelerators and for production of fine focusing beams for industrial microelectronics technologies. Often, surface ion sources are used due to their simple construction and easiness of operation. However, they can only deliver a very small range of elements, mostly alkaline and alkaline earth ions and a few other species. Laser ablation in vacuum opens the possibility to produce ion beams even from transition metals or compound materials. The drawback of this technique is the high emittance of the beam. The presented ion source will counteract this drawback by using He buffer gas to stop the ions and extracting them through optimized RF funnels into high vacuum conditions.

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