A 17: Collisions, scattering and correlation phenomena

Time: Wednesday 14:00–15:30 Location: A-H1

Invited Talk A 17.1 Wed 14:00 A-H1

Isomer depletion via nuclear excitation by electron capture with electron vortex beams — •Yuanbin Wu[1], Christoph H. Keitel[1], and Adriana Pálffy[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, D-91058 Erlangen, Germany

Long-lived excited states of atomic nuclei, known as nuclear isomers, can store a large amount of energy over long periods of time, with a very high energy-to-mass ratio. Dynamical external control of nuclear state population has proven so far very challenging, despite ground-breaking incentives for a clean and efficient energy storage solution. Here, we describe a protocol to achieve the external control of the isomeric nuclear decay via the process of nuclear excitation by electron capture [1] with electron vortex beams whose wavefunction has been especially designed and reshaped on demand [2]. This can lead to the controlled release of the stored nuclear energy. We show theoretically that the use of tailored electron vortex beams can increase the depletion of isomers by 2 to 6 orders of magnitude compared to so far considered depletion mechanisms and provides a handle for manipulating the capture mechanism [2].

[1] Y. Wu, C. H. Keitel, A. Pálffy, Phys. Rev. Lett. 122, 212501 (2019).
[2] Y. Wu, S. Gargiulo, F. Carbone, C. H. Keitel, A. Pálffy, arXiv: 2107.12448.

A 17.2 Wed 14:30 A-H1

Spectroscopy of metastable states of Si$^-$ — •Suvam Singh, Chunhai Lyu, Christoph Keitel, and Zoltán Harman — Max Planck Institute for Nuclear Physics, 69117 Heidelberg, Germany

In this work [1], we have calculated photodetachment cross sections (PDCS), electron affinities, fine-structure splittings, transition energies, and radiative lifetimes of all the metastable states of the Si$^-$ ion. All atomic state functions for the description of Si and Si$^-$ ion have been generated by the Multiconfiguration Dirac-Hartree-Fock method. Here, we have used the grasp2K and RATIP codes to carry out dedicated calculations of the PDCS of all anionic states of Si$^-$ at two specific photon energies, namely, at 0.89 eV and 1.95 eV. The choice of the photon energies is motivated by very recent low-background measurements with the Cryogenic Storage Ring (CSR) of the Max Planck Institute for Nuclear Physics (MPIK) in Heidelberg, Germany. The PDCS are used in analyzing experimental data obtained by the CSR at MPIK. To independently predict the electron affinities, fine-structure splittings, transition energies, and radiative lifetimes, we have used the MCDHF method in combination with the relativistic configuration interaction approach. These calculations were performed using the GRASP2018 code, performing a systematic expansion of the atomic states in terms of a large number of configuration state functions to obtain accurate predictions. Detailed results will be presented during the conference.

Reference: [1] D. Müll *et al.*, Phys. Rev. A, **104** (2021) 032811.

A 17.3 Wed 14:45 A-H1

First experimental results on electron-impact ionisation of La^{1+} with a new energy-scan systems — •B. Michel Döhring[1,2], Alexander Borovik Jr[1], Kurt Huber[1], Alfred Müller[1], and Stefan Schippers[1] — [1]Justus-Liebig-Universität Gießen — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt (Germany)

For the investigation of resonance structures in electron-impact ionisation cross sections one needs to be able to scan these cross sections in small electron-energy steps. In order to meet this requirement we have developed a new fast energy-scan system for a new recently commissioned high-power electron gun [1]. This new gun extends the range of experimentally available electron energies from previously 1 keV [2] to now 3.5 keV. As compared to the old gun, the new one has more electrodes. This enables us to more flexibly control the transport of the electron beam. However, this also required a completely new development of the scanning system. We will report on first experimental results on single and multiple ionisation of La^{1+} ions. The new data compare well with earlier measurements [3] and extend the known energy range by a factor of two.

[1] A. Müller et al., 1988 Phys. Rev. Lett. **61** 70.
[2] B. Ebinger et al., 2017 Nucl. Instrum. Meth. B **408** 317.
[3] A. Müller et al., 1989 Phys. Rev. A **40** 3584.

A 17.4 Wed 15:00 A-H1

Dielectronic recombination of Ne^{2+} at the Cryogenic Storage Ring — •Leonard W. Isberner[1], Manfred Grieser[2], Robert von Hahn[2], Zoltán Harman[2], Ábel Kálosi[3], Christoph H. Keitel[2], Claude Krantz[4], Daniel Paul[3], Stefan Schippers[1], Suvam Singh[2], Andreas Wolf[2], and Oldřich Novotný[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [3]Columbia Astrophysics Laboratory, Columbia University, New York, 10027 New York, USA — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany

In the past three decades, electron-ion recombination has been successfully investigated by employing the merged-beams technique in magnetic heavy-ion storage rings. Because of the limited magnetic rigidity, recombination studies were restricted to ions with low mass-over-charge ratio. The combination of mass-independent storage in electrostatic storage rings with the excellent vacuum conditions of cryogenic environments is a promising approach to enable the investigation of recombination processes in low-charged heavy ions, which are important, e.g., for astrophysics. Here we report on a first recombination study of $\mathrm{Ne}^{2+} + \mathrm{e}^- \rightarrow \mathrm{Ne}^+$ in the electrostatic Cryogenic Storage Ring (CSR) located at the Max Planck Institute for Nuclear Physics in Heidelberg. We have observed resonant recombination features in agreement with quantum-theoretical predictions. Our results clearly demonstrate the feasibility of atomic recombination studies with heavier species at CSR.

A 17.5 Wed 15:15 A-H1

Three-charge-particle collwions between antiprotons ($\bar{\mathrm{p}}$) and muonic hydrogen atoms (H_μ) at low-energies — •Renat A. Sultanov — Odessa College, Department of Mathematics, 201 W. University Blvd., Odessa, Texas 79764, USA

A detailed few-body treatment is performed for two low-energy three-charge-particle reactions. The first reaction is between an antiproton $\bar{\mathrm{p}}$ and a ground state muonic deuterium $\mathrm{D}\mu^-$ - a bound state of a negative muon μ^- and the deuterium nucleus D. The second reaction is between $\bar{\mathrm{p}}$ and a muonic tritium $\mathrm{T}\mu^-$. In the first reaction additional final-state nuclear $\bar{\mathrm{p}}\mathrm{D}$ interaction inside the ($\bar{\mathrm{p}}\mathrm{D}$) antiprotonic atom is taken into account and the effect of the strong $\bar{\mathrm{p}}\mathrm{D}$ nuclear forces on the reaction cross-sections and rates is computed. It was found that at low energy collisions, $E_{coll} \sim 10^{-3}$–10^{-1}eV, the influence of the strong interaction is significant, i.e. the reaction cross sections and rates are increased by ~300%. In the second reaction the final state $\bar{\mathrm{p}}\mathrm{T}$ nuclear interaction has also been included and the effect was approximately estimated. Modified Faddeev-type equations have been applied to the three-body systems [1, 2].

1. R. A. Sultanov, D. Guster, and S. K. Adhikari, *Atoms* **6**, 18 (2018).
2. R. A. Sultanov and D. Guster, *J. Phys. B: At. Mol. Opt. Phys.* **46**, 215204 (2013).