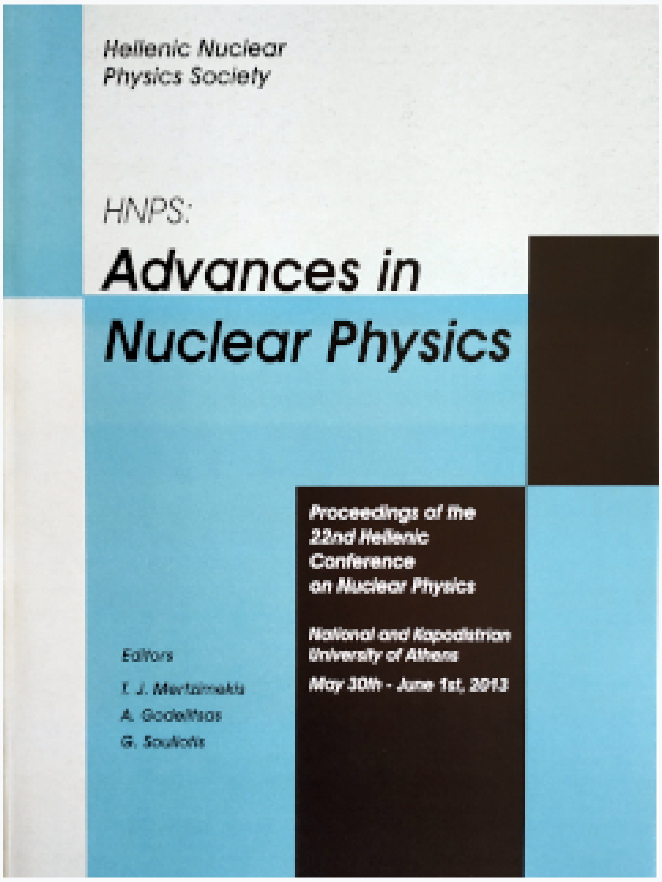
Annual Symposium of the Hellenic Nuclear Physics Society

Τόμ. 21 (2013)

HNPS2013



APAPES - Atomic Physics with Accelerators: Projectile Electron Spectroscopy

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doi: 10.12681/hnps.2022

APAPES - Atomic Physics with Accelerators: Projectile Electron Spectroscopy

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Abstract

The only existing heavy-ion accelerator in Greece, the 5.5 MV TANDEM at the National Research Center "Demokritos" in Athens has been used to date primarily for investigations centering around nuclear physics. Here, we propose to establish the new (for Greece) discipline of Atomic Physics with Accelerators, a strong field in the EU with important contributions to fusion, hot plasmas, astrophysics, accelerator technology and basic atomic physics of ion-atom collision dynamics, structure and technology. This will be accomplished by combining the existing interdisciplinary atomic collisions expertise from three Greek universities, the strong support of distinguished foreign researchers and the high technical ion-beam know-how of the TANDEM group into a cohesive initiative.

Using the technique of Zero-degree Auger Projectile Spectroscopy (ZAPS), we shall complete a much needed systematic isoelectronic investigation of K-Auger spectra emitted from collisions of pre-excited ions with gas targets using novel techniques. Our results are expected to lead to a deeper understanding of the neglected importance of cascade feeding of metastable states [1] in collisions of ions with gas targets and further elucidate their role in the non-statistical production of excited three-electron states by electron capture, recently a field of conflicting interpretations awaiting further resolution.

Keywords: APAPES, Electron Spectroscopy, Ion Sources, Hemispherical Analyser, Auger, Projectile,

1. Electrostatic Analysers

Electrostatic energy analysers are irreplaceable as high-resolution monochromators and energy spectrometers of ions and electrons in various atomic collision experiments, as well as in almost every experimental set-up for surface characterization. In general, a Hemispherical Deflector Analyser (HDA)combined with a cylindrical input-lens-system is used to measure the energy of the scattered electrons in collision experiments. Since the electrostatic field of the HDA differs from the ideal uniform field, an extensive study of the fringing field developed is needed in order to avoid phenomena such as distorted trajectories,

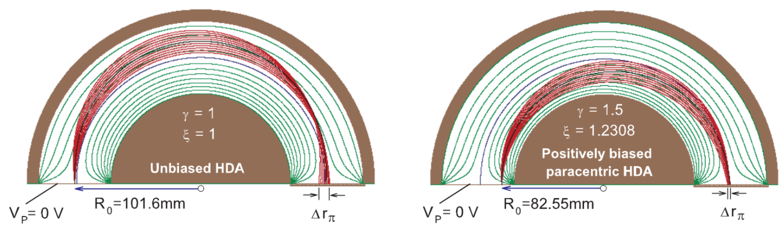

Figure 1: Electron trajectories in unbiased entry and a positively-biased paracentric entry [2]. The improvement in focusing of the paracentric HDA is clearly obvious.

the degradation of the first-order focusing and corresponding loss in energy resolution and/or transmission. Extensive study is conducted for the application of corrections, such as biased paracentric entry HDA(Fig: 1).

2. Proposed Set-Up

This ZAPS set-up is the only existing high-efficiency, high-resolution system in the world making it about 15-20 times more efficient than conventional single channel devices (e.g. two-stage parallel plate electron spectrometers [3]).Thus, it is ideally suited for use in the electron spectroscopy of weak ion beams such as the ones called for in this proposal. Additionally, the paracentric entry of the HDA is a novel feature adding further high resolution capability not available to conventional centric HDAs [4]. The set-up, as seen in Fig: 2, is carefully designed to apply doubly-differential pumping. The projectile electrons will run through the analyser and measured using a PSD (Position-Sensitive Detector).

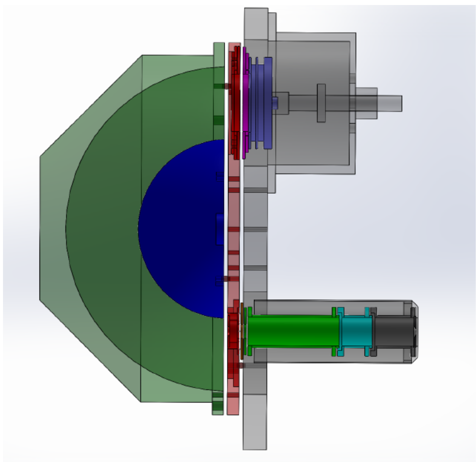

Figure 2: CAD model of the Hemispherical Deflector Analyzer, with a paracentric entry. Each color represents a different potential.

3. Actual Set-Up

Since the proposed set-up is built from scratch, detailed design has been made in all stages of the assembly. Every part of the beam-line is carefully designed with CAD programming, with the use of SolidWorks^{TM} program(Fig: 3), before being constructed and implemented into the set-up. A number of prototypes have been developed for the set-up, while there is a continuous research for all possible improvements on the set-up. All basic vacuum tests have been performed with success, and after the arrival of some elementary parts, the first beam tests were performed in the last week of February, 2014.

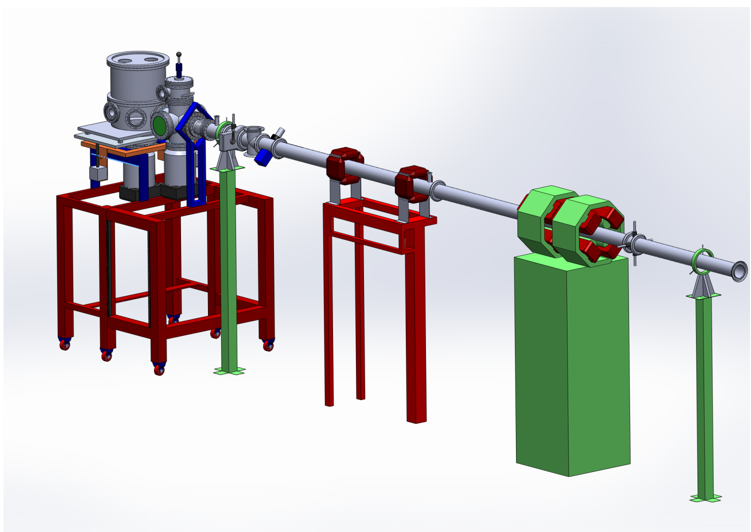

Figure 3: CAD model of the set-up showing the beam line with the dipole magnet, the magnetic steerers, the target 5-way cross and the vacuum chamber housing the HDA.

4. Expected Results

The various 1s2s2l lines observed in the spectrum of Fig. 4, must result from the capture of a target electron to one of the possible C^{3+}(1s2s2l) states. Basic quantum mechanics requires the spin coupling of a 2p electron to the 1s2s ^{3}S state to yield 1s2s2p ^{4}P quartet and 1s2s2p ^{2}P doublet states in the ratio 2 to 1 or R=(1s2s2p ^{4}P)/(1s2s2p ^{2}P)=2. However, the values of R extracted from the spectra of Fig. 4 are much larger with R about 6-9. Our intention is to explore this ratio both experimentally and theoretically for first row ions.

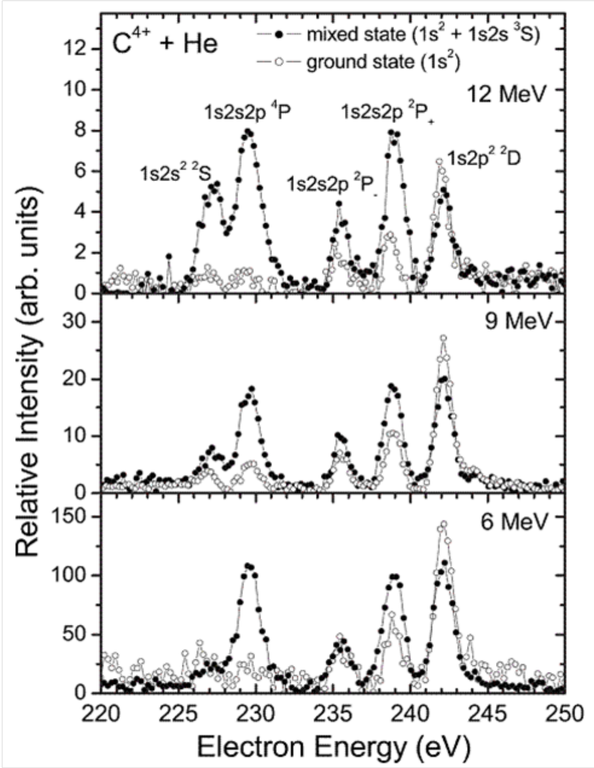

Figure 4: K-Auger spectra from mixed and pure ground state C^{4+} beams at three collision energies [5]

Acknowledgments

Co-financed by the European Union (European Social Fund - ESF), and Greek National funds through the Operational Program “Education and Lifelong Learning” of the National Strategic Reference Framework (NSRF) - Research Funding Program: THALES. Investing in knowledge society through the European Social Fund (Grant No. MIS 377289)

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