Atomic Physics with Accelerators: Projectile Electron Spectroscopy Work Package 3.1: Design of experimental apparatus

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0^o Auger projectile spectroscopy - Design of experimental apparatus

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1 Introduction

The main chamber along with the spectrometer were brought from KSU (Kansas State University), where they were in use through 2007. Thus, for this part of the apparatus there were no significant changes made. However, a new support stand had to be build for the chamber and is described in more detail next. The principle of operation for the experimental apparatus

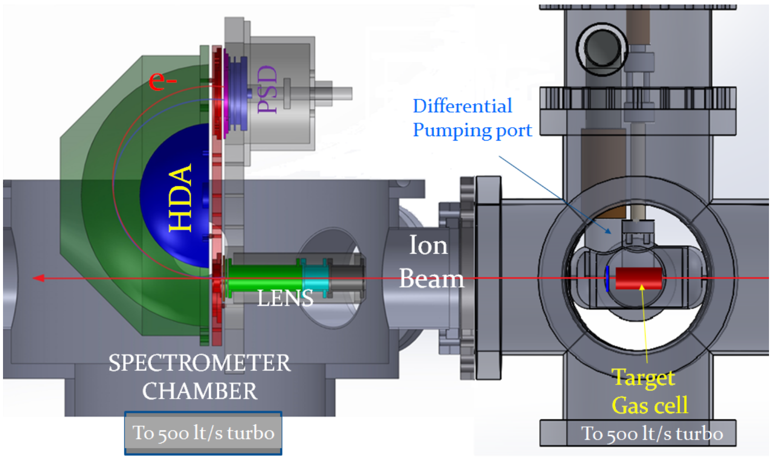

Figure 1: The experimental apparatus. The red arrow shows the beam alignment along with the (forward) emitted electrons.

is explained elsewhere.

2 Assembly considerations

The spectrometer chamber along with the analyser were modelled in full detail in the Solidworks^{TM}CAD software for maximum design efficiency and to avoid any problems regarding the occupying space. The original chamber came with an XYZ alignment base table top. In the machine shop a supporting table was constructed that originally had four legs. While the assembly of the apparatus advanced, there was a definite need for further weight support for the target 6-way cross. This resulted in the solution shown in Fig. 2 which depicts the final support stand for the apparatus. The upstream extension of the table was carefully designed so that the space beneath the target has the standard width of a typical rack unit. Additionally, adjustable mounting feet were installed in every corner of the table for maximum stability and control of the position and orientation of the table. Additional support was required and assembled (green beam in Fig. 2 for the support of the 3^{rd} turbo pump and to secure a stable part of the beamline as the reference point for the apparatus alignment. After that, a bellow

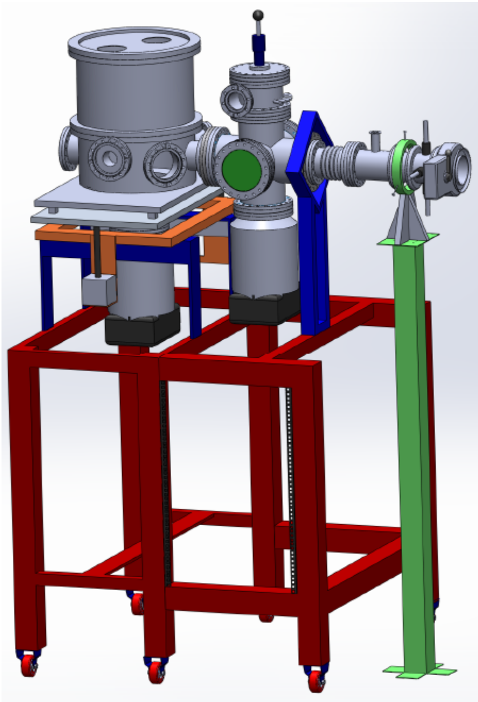

Figure 2: The experimental apparatus assembly designed with CAD software.

of standard beam-line diameter was placed between the beam line and the chamber to ensure the required movement independence for the alignment.

3 SIMION study of optimal lens voltages

3.1 Introduction

The hemispherical deflector analyzer (HDA) is one of the most widely used electrostatic energy selectors in low energy atomic collision physics [1]. However, the first-order focusing characteristics of the HDA are impaired due to the fringing fields created at the electrode entry boundaries, as seen in Fig. 3. In the conventional HDA, fringing fields generally produce an image with larger angular aberrations at the dispersion plane from that predicted for the ideal (no fringing fields) HDA leading to a substantial deterioration in its energy resolution. Partial recovery of the high resolution attributes of the ideal HDA can be attained by incorporating additional electrodes in various fringing field correction schemes. This drawback can also be readily overcome without using any type of additional fringing field corrector electrodes, in an arrangement known as the “biased paracentric” HDA used here [2].

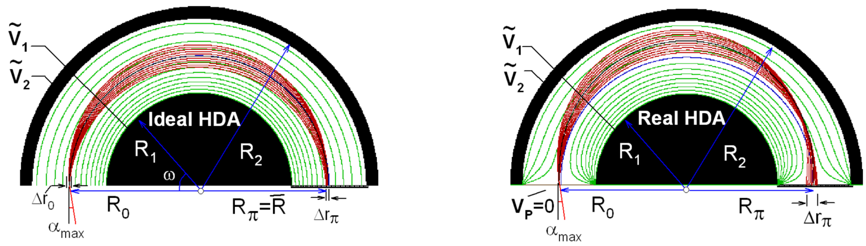

Figure 3: Hemispherical Deflector Analyser. On the left, the ideal case is presented, where there are no fringing fields, and the entrance slit is at $\bar{R} = \frac{R_1+R_2}{2}$. On the right, the fringing fields are introduced, clearly showing a deterioration of the exit focus since this is now seen to move inside the HDA.

3.2 Paracentric Entrance Analyser with Injection Lens

To use the HDA under first order focus conditions and further improve overall resolution by pre-retardation an injection lens for the electrons needs to be used. There are three major advantages that the injection lens offers:

1. The lens is able to control the diameter of the incoming electron beam, thus, providing an effective virtual entry aperture whose size determines the attainable energy resolution R. This is given by $R = \frac{w_1+w_2}{D_\gamma} + \alpha^2_{max}$, where w_1 is the width of the entrance slit.
2. Utilizing an injection lens, the user is capable to control the focal point at the entrance of the analyser, thus improving overall resolution.
3. By decelerating the electrons in the lens (just before the last element which is at the potential as the HDA base plate) overall resolution is improved in inverse proportion to the deceleration factor F.

Since there is no analytical solution for the values of the optimal lens voltages, these can be found by two different ways. The first is to empirically find them by trial and error, using target Auger signals or an electron gun. The second is to use a brute force method in simulation software, like SIMION^{TM}[3]. The first method had been used in the past (Benis PhD thesis [4]) resulting in empirical values used as starting points. In APAPES, we used these empirical results as well as new results obtained by an optimization technique performed in simulation and described in various reports and conference proceedings [5, 6]. A final paper (in preparation) will give the final results of these investigations. The SIMION code consists in the optimization of the HDA energy resolution as a function of the two free lens voltages V_{L4} and V_{L5}, which were allowed to be varied over the entire available voltage space in the simulations [5, 6].

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References

[1] T. J. M. Zouros and E. P. Benis, J. Electron Spectrosc. and Relat. Phenom. **125**, 221 (2002).

[2] M. Dogan, M. Ulu, G. G. Gennarakis, and T. J. M. Zouros, Review of Scientific Instruments **84**, 043105 (2013).

[3] http://www.simion.com

[4] E. P. Benis, Ph.D. dissertation, Dept. of Physics, University of Crete, 2001, (unpublished).

[5] T. Zouros *et al.*, Microscopy and Microanalysis **21**, 148 (2015).

[6] G. Martnez *et al.*, Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms (2015).