20th Summer School and International
Symposium on the Physics of Ionized Gases

20th SPIG

September 4 - 8, 2000, Zlatibor, Yugoslavia

CONTRIBUTED PAPERS

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ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES AND PROGRESS REPORTS

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PREFACE

This book contains the Contributed papers and abstracts of the Invited lectures, Topical invited lectures and Progress reports to be presented at the 20th Summer School and International Symposium on the Physics of Ionized Gases – SPIG 2000. The Symposium will be held in Zlatibor, Yugoslavia, from September the 4^{th} to September the 8^{th}, 2000.

The Contributed papers are related to the following research fields: Atomic Collision Processes, Particle and Laser Beam Interaction with Solids, Low Temperature Plasmas and General Plasmas. The length of a Contributed papers is limited to a maximum of four pages, each of them presenting an original work with sufficient amount of scientific information.

The Scientific and Organizing Committees believe that this Symposium, with its Invited lectures and Contributed papers, managed to maintain the high scientific level established by previous SPIG conferences in the 40 years long tradition. To mark the occasion of the 20^{th} SPIG a special, *fifth*, section was introduced dealing with the history of SPIG. A separate session will be arranged with a lecture on the history of SPIG. All the participants, especially those that took part in early SPIG conferences are invited to share their memories, impressions and thoughts on the future of the conference.

The Organizers of the 20th SPIG are the Institute of Physics, Faculty of Physics – University of Belgrade and Institute of Nuclear Science "Vinča". The Organizer gratefully acknowledges the support of the Ministry of Science and Technology of the Republic of Serbia and Ministry of the Development, Science and Environment of the Federal Republic of Yugoslavia. We also acknowledge support of PTT Serbia and Jumko. The Organizing committee appreciates the help from the previous Organizers, Mr. I. Videnović in particular.

The participants have been asked to send their papers camera ready, so no typing, spelling and grammatical errors have been corrected in the course of preparation of this book.

June, 2000. Editors

THE FOCAL PROPERTIES OF THREE-ELEMENT ELECTROSTATIC ELECTRON LENSES VERIFIED BY SIMULATIONS IN THE SIMION PROGRAM

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1. INTRODUCTION

There are frequent needs for an electron optical system to form an image at a fixed position while scanning the electron energy over a wide range. Such focusing can be achieved with three-element electron lenses, since their focal properties depend on two voltage ratios and the desired focal condition may be achieved by pairs of values of these ratios. These pairs of values form the *focal locus* of the lens. Presently, accurate calculations as well as experimental data of focal properties of three-element electron lenses are available. In this contribution, however, we present results obtained by simulations in the SIMION program. The aim of this effort is both to verify focal properties of three-electron lenses and to master possibilities of using SIMION.

The procedure for the prediction of focal loci of three-element electron lenses is described by Heddle [1]. The method enables eight pairs of voltage characteristic ratios to be found from known two-electron lens properties. Additional constraints to the curve were made based on physical arguments. The first measurements of the focal properties of three-element electrostatic electron lenses were published by Heddle and Kurepa [2]. The scheme of electron optical system is shown in Fig. 1. The measurement procedure was to select values of V_1 and V_3 and to adjust V_2, while observing the current to the electron beam collector. In general, two maxima were found corresponding to the two focal loci. One of the maxima was found to be sharper than the other, what reflects different magnification.

Using the SIMION program we made a model of electron optical system described above. Also, the model of an other three-element electron optical system used in our laboratory was made.

2. THE SIMION PROGRAM

All results presented in this contribution were made using the commercial program SIMION ver. 6.0 [3]. At the beginning, points belonging to electrodes should be plotted. After that, the program calculates the electric field in all other points of the given space. The number of points determines the resolution of the space and is limited by amount of RAM of the computer. The more points one has, the more accurate results will be. The program computes potential field by numerical solving the Laplace equation. This version of SIMION allows making programs which enable a continual change of starting conditions and electrode voltages. We used other commercial programs (Origin 5.0, mostly) to handle the collected data.

3. RESULTS

Results of our focal loci calculations for two different three-element electron lenses are shown in Fig. 2 and Fig. 3. The experimental results corresponding to the same lenses, including theoretically calculated ones, are also shown. Our procedure was to select the ratio V_3/V_1 and to change the voltage V_2 until the electron trajectory crosses the X-axis in the desired point, with a relative error smaller than 0.01 percent. Electrons were ejected from the plane cathode with the energy of 100 meV and the distance of the cathode from the first aperture was (1/5) in units of lens diameter (this should be close to the real experiment). The voltage on the first electrode V_1 was 10 V. Values of ejected electron thermal energy and the voltage V_1 were adjusted to generate the same slope of the curve for the first lens (Fig. 2) as in the original experiment. These values were same for the parameters of lens given in Fig. 3.

Results for calculated lens magnifications of the lens of Fig. 3 are shown in Fig. 4. Theoretically calculated points by Heddle and Kurepa are also shown. The procedure was to obtain the electron trajectory distance from the X-axis in the focal plane. Therefore, for different ratios V_3/V_1, this distance was uniquely related with the value of V_2, i.e. with focal locus of the lens. The lens magnification was calculated by dividing the obtained distance with the electron trajectory distance in the starting point. The starting elevation angle of ejected electron was equal to zero.

All above presented calculations were performed by simulating just a single electron trajectories. In the real experiment one has an electron beam passing through lenses. A simulation closer to real conditions was performed, too. We made a model of a three-element electron lens used as a part of analyzer system in our laboratory [4].

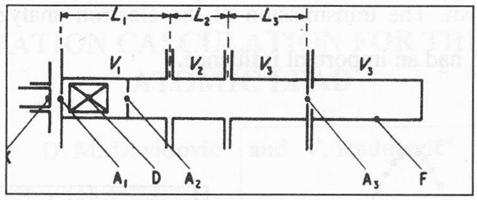

Figure 1. A three-element lens consisting of coaxial cylinders separated by gaps of (1/10) of their internal diameter

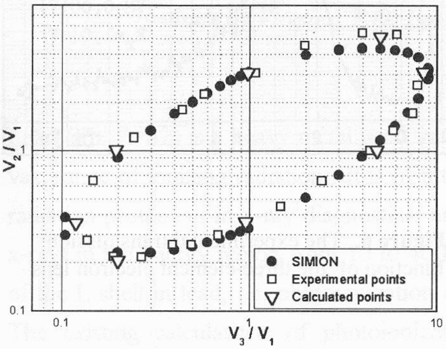

Figure 2. The focal locus of a lens with $L_1 = 5.17$; $L_2 = 2.26$; $L_3 = 5.16$ in units of the internal lens diameter

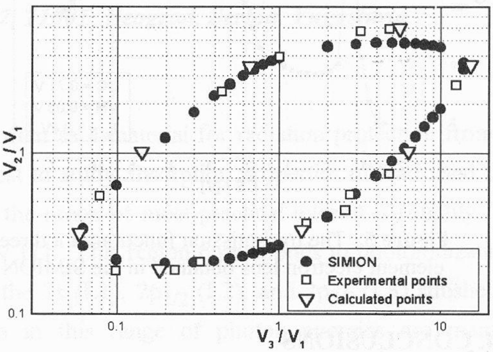

Figure 3. The focal locus of a lens with $L_1 = 4.37$; $L_2 = 3.85$; $L_3 = 3.06$ in units of the internal lens diameter

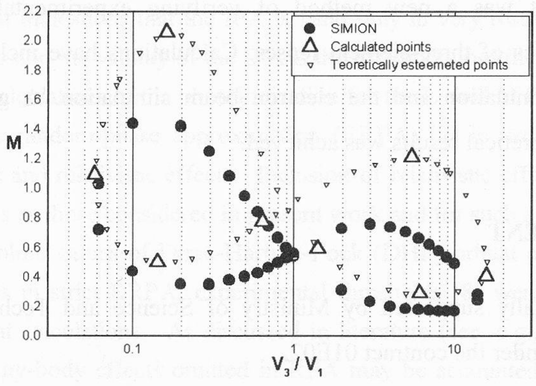

Figure 4. The magnification of a lens with $L_1 = 4.37$; $L_2 = 3.85$; $L_3 = 3.06$ (Fig. 3)

Electrons were ejected with different starting elevation angles and different starting Y coordinates. The voltage of central electrode was changed in steps of 0.2 V. All other parameters were as in the real experiment. The calculated transmission is shown in Fig. 5. This transmission is related with focal properties of the lens. Two maxima correspond to beam foci at the final aperture. The different sharpness of maxima is due to different magnifications. In Fig. 6 the transmission function obtained in the real experiment under the same conditions is shown. The transmission of the electron analyzer, which was a double mirror electron analyzer, had an important influence.

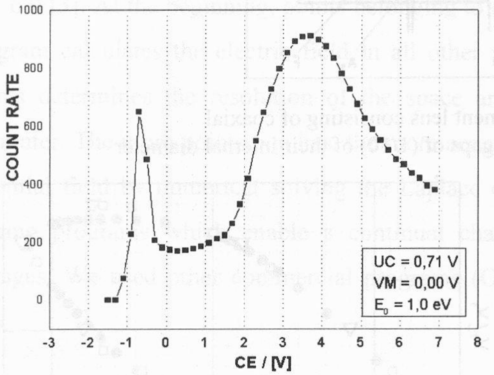

Figure 5. The transmission function of a three-element electron lens obtained in the SIMION

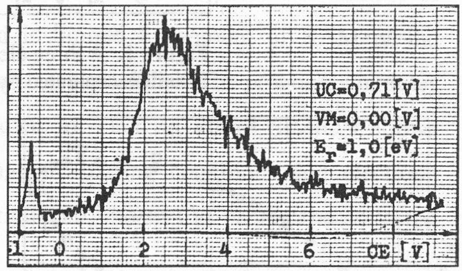

Figure 6. The experimental transmission function of the three-element electron lens

4. CONCLUSIONS

The focal properties of three-element electrostatic electron lenses were calculated using the SIMION program. It was a new method of verifying experimentally and theoretically obtained characteristics of three-element lenses. Calculations have included both the single electron trajectory simulation and the electron beam simulation. A good agreement with experimental and theoretical results was achieved.

ACKNOWLEDGMENT

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