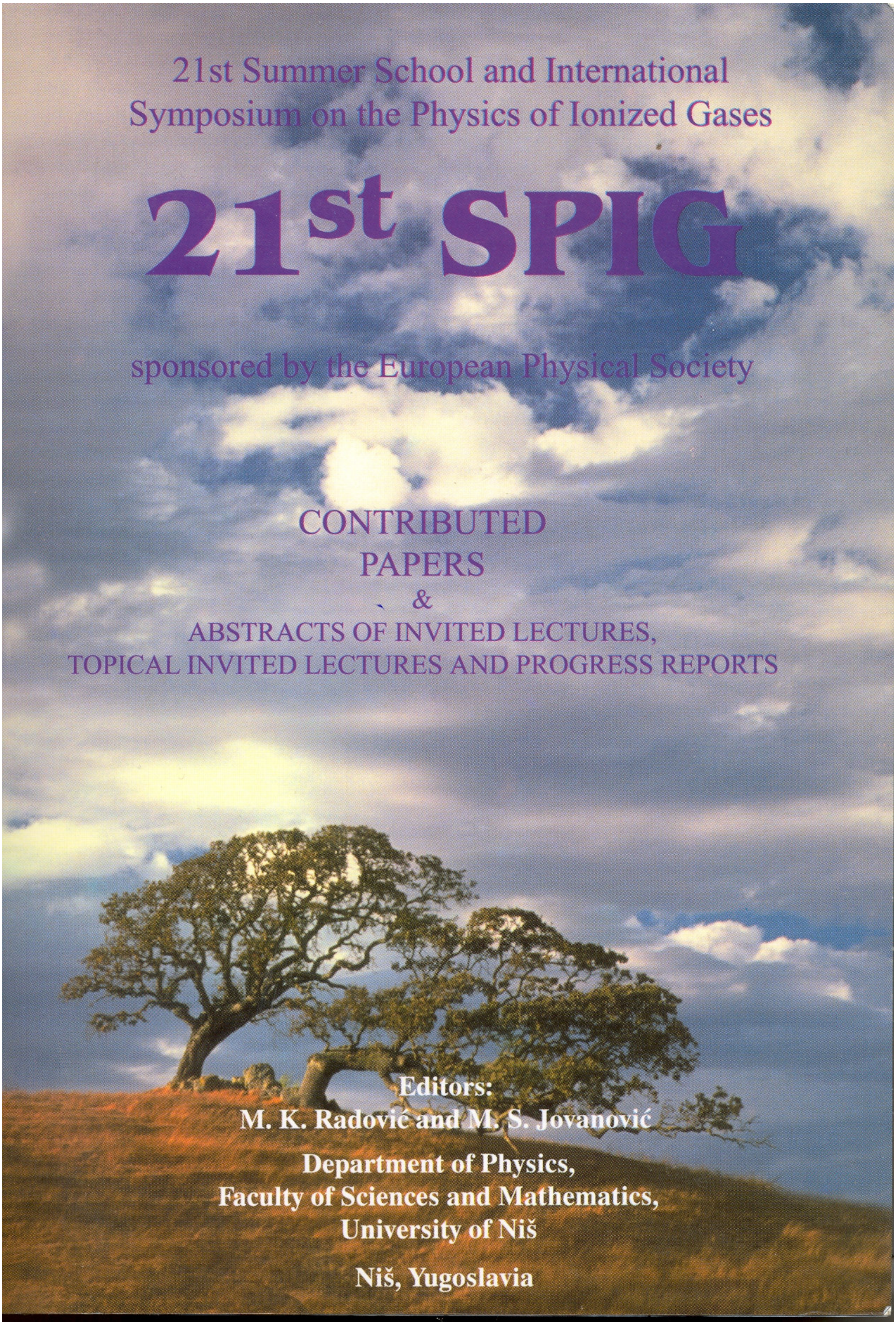

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ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES AND PROGRESS REPORTS

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INVESTIGATION OF TRANSMISSION OF FOUR-ELEMENT ANALYZER ELECTRON LENSES ON THE APPARATUS "UGRA" BY SIMULATIONS IN THE "SIMION" PROGRAM

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Abstract. In this contribution we present transmission functions for four-element analyzer electrostatic electron lenses used on the apparatus "UGRA", placed in the Laboratory of Atomic Collisions, Institute of Physics, Belgrade. The transmission of analyzer system was investigated by simulations in program "SIMION" both for the energy-loss and the impact energy mode of operation. Low energy range of analyzed electrons (0 to 20 eV) as well as medium (80 to 150 eV) were considered. Also, we present a few experimentally obtained results that correspond to the calculations.

1. SIMULATIONS IN THE PROGRAM "SIMION"

The method we present in this work has been already used for the examination of the properties of three-element electron lenses and very good agreement with previous experimental and theoretical data was achieved [1]. In brief, the commercial program SIMION ver. 6.0. [2] was used for modeling the electron-optical system and calculation of the potential fields. Additional programming we had done, allowed us to change the electrode potentials and starting parameters of the electron trajectories (according to desired mode of operation) and to define the conditions for the collection of data.

The aim of this work is the examination of transmission of the analyzer electron lens system on electron spectrometer UGRA. The energy distribution of electrons (ions) leaving the interaction chamber is obtained by analyzing system which consists of four-element electron lens and double cylindrical mirror analyzer (DCMA) with an energy resolution of $\Delta\varepsilon/\varepsilon = 0.03$. Two types of simulations were made whether the position of focus loci with respect to the final aperture or the whole transmission of the lens was observed. In both cases, positions and transmission were considered as a function of the final (UC) electrode lens potential.

2. FOUR-ELEMENT ELECTRON LENS

The scheme of analyzer lens is presented in Fig. 2.1. It is a simple four element cylindrical electron lens the roll of which is to accept and accelerate (retard) the analyzing particles and focus them into the DCMA.

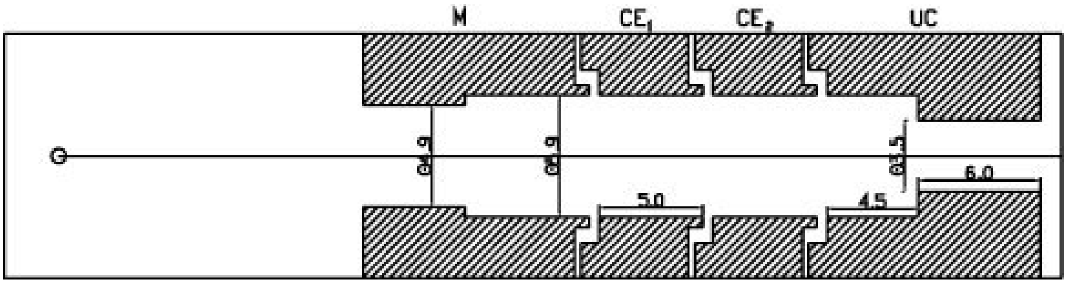

Fig. 2.1. The four-element analyzer electron lens

The first electrode (M) is always on the ground potential which is the potential of the interaction chamber. The length of this electrode disables the influence of the potentials of inner electrodes to the interaction region. The fourth electrode (UC) is always on the potential of the inner cylinder of DCMA. By this potential the energy of the selected electrons is defined. The two central electrodes (CE1 and CE2) are used to focus the electrons (ions) onto the entrance of DCMA. According to the present experimental configuration the potentials of these electrodes are defined with respect to the UC.

3. EXAMINATION OF TRANSMISSION IN THE ENERGY LOSS MODE

In this mode of operation the potential of the UC electrode was successively increased. At the same time, the electron energy was decreased providing the constant electron energy at the final aperture.

3.1. Low electron energies

In Fig 4.1. and Fig. 4.2. both the transmission and focal loci position were presented as a function of starting electron energy in the range from 0 to 12 eV for the present experimental configuration where the potentials of CE1 and CE2 are defined with respect to UC. Different ranges of UC potentials correspond to different selection of energy of electrons passing through the DCMA.

The transmission functions for possible configurations of operation of four-element electron lens are presented in Fig. 4.3. It can be seen that the double imaging configuration gives the most constant transmission. However, the examination of the angle distribution at the final aperture suggests a great signal decrease in this case.

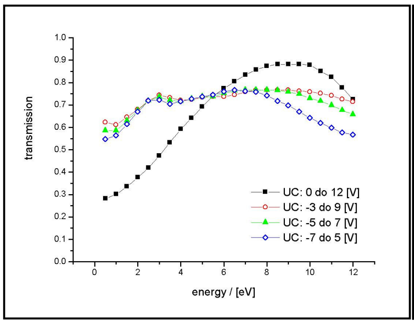

Fig. 4.1. Transmission of an analyzer lens as a function of electron energy.
CE1 = 26.5 V; CE2 = 11.7 V

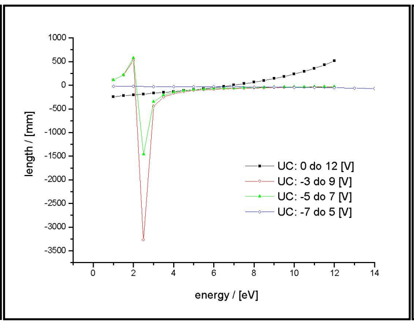

Fig. 4.2. Focal loci of a lens as a function of electron energy.
CE1 = 26.5 V; CE2 = 11.7 V

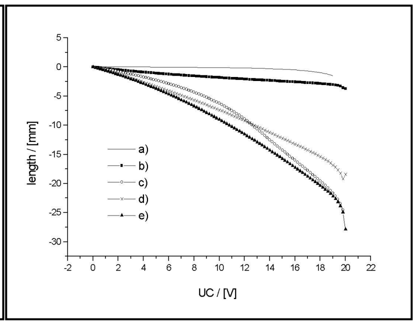

Fig. 4.3. Focal loci of a lens as a function of UC potential.
a – $CE1 = CE1_0*(E_0 - \Delta UC)/E_0$
b – double imaging
c – direct imaging
d – three-elemnt lens (M = CE1)
e – three-elemnt lens (CE2 = UC)

3.2. Medium electron energies

In Fig. 4.4. we present the transmission function for analyzer lens in energy loss mode of operation for 80 eV impact electron energy. It is rather linear with energy loss and small due to imposed restrictions in angular and radial divergence at the final aperture. Also, the value of calculated transmission depends on used set of starting conditions. In Fig. 4.5. the corresponding experimentally obtained energy loss spectrum for electron-impact excitation of Ar is given. The structure at about 12 eV corresponds to the excitation of 4s levels and is dominantly determined by the $4s'[1/2]_1$ state. However, due to low resolution in this electron energy region the states cannot be split apart.

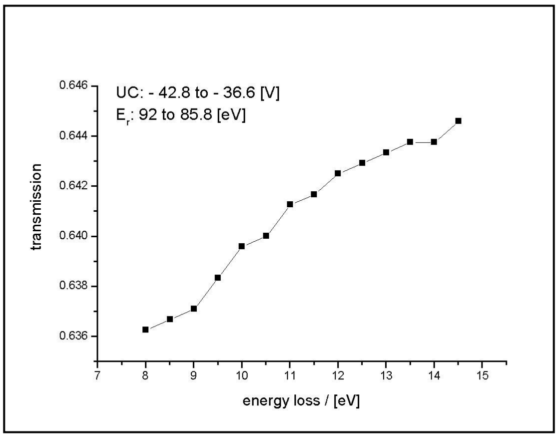

Fig. 4.4. Transsmission function obtained in the SIMION program.

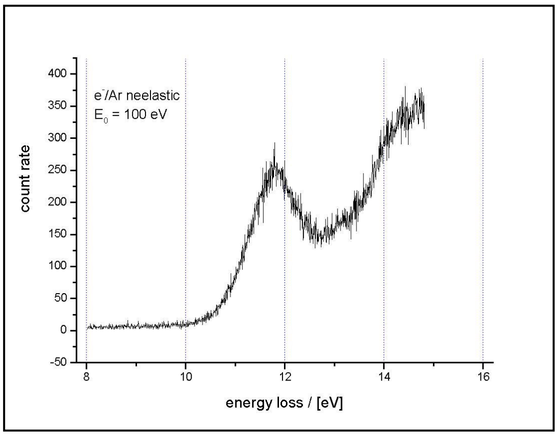

Fig. 4.5. Experimentally obtained energy loss spectrum for electron impact excitation of Ar.

5. EXAMINATION OF TRANSMISSION IN THE IMPACT ENERGY MODE

In this mode of operation the potential of the UC electrode was successively decreased. At the same time, the electron energy was increased providing the constant electron energy at the final aperture.

The transmission function for the impact energy mode in the medium electron energy range (80 to 150 eV) is presented in Fig. 5.1. It is quite constant which is of great importance for the measuring of the impact energy dependence of differential (IEDCS) cross sections for electron-atom interactions. The IEDCS for elastic scattering of electrons on Ar at 90 ^{o} of scattering angle is presented in Fig. 5.2.

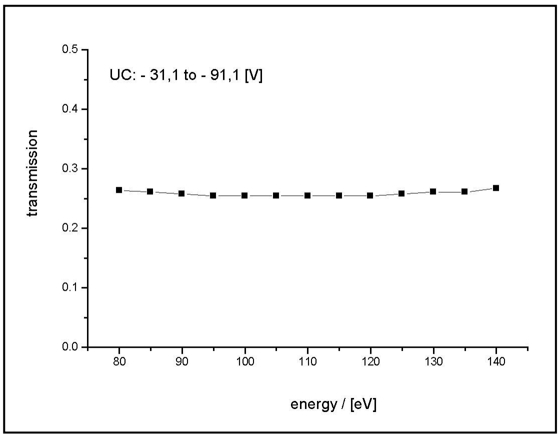

Fig. 5.1. Transsmission function obtained in the SIMION program.
CE1UC = 0 V; CE2UC = - 34.1 V

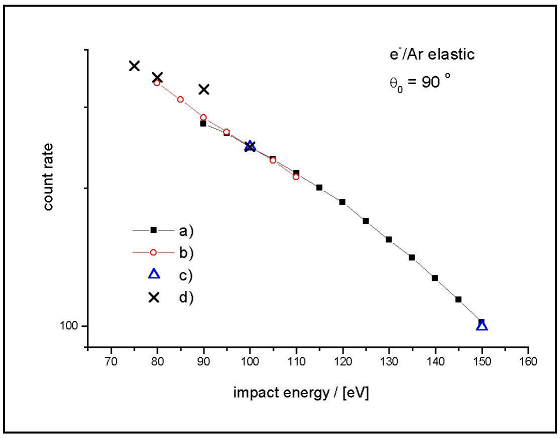

Fig. 5.2. IEDCS for elastic e^-/Ar scattering at 90 ^{o} of scattering angle: a) our results; b) Cvejanović *et al* [3]; c) Williams *et al* [4]; d) Panajotović *et al* [5]. The results of b), c) and d) are normalized at 100 eV.

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