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# 23<sup>rd</sup> Summer School and International Symposium on the Physics of Ionized Gases

August 28<sup>th</sup>-September 1<sup>st</sup> 2006, Kopaonik, Serbia

## CONTRIBUTED PAPERS

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ABSTRACTS of INVITED LECTURES,  
TOPICAL INVITED LECTURES and PROGRESS REPORTS

Editors:

Nenad S. Simonović  
Bratislav P. Marinković  
Ljupčo Hadžievski

23<sup>rd</sup> SPIG CONTRIBUTED PAPERS



Institute of Physics  
Belgrade, Serbia

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**CONTRIBUTED PAPERS**

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**ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED  
LECTURES and PROGRESS REPORTS**

*Editors*

**Nenad S. Simonović, Bratislav P. Marinković and Ljupčo Hadžievski**

**Institute of Physics  
Belgrade, Serbia**

**Belgrade, 2006**

CONTRIBUTED PAPERS & ABSTRACTS OF INVITED LECTURES,  
TOPICAL INVITED LECTURES and PROGRESS REPORTS  
of the  
23<sup>rd</sup> SUMMER SCHOOL AND INTERNATIONAL SYMPOSIUM  
ON THE PHYSICS OF IONIZED GASES

28 August – 1 September 2006  
National Park Kopaonik, Serbia

*Editors*

**Nenad S. Simonović, Bratislav P. Marinković and Ljupčo Hadžievski**

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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 23<sup>rd</sup> Summer School and International Symposium on the Physics of Ionized Gases – SPIG 2006. The symposium will be held in National Park Kopaonik, Serbia, from August 28 to September 1, 2006. The meeting is organized under the auspices and with the support of the Ministry of Science and Environmental Protection, Republic of Serbia. The conference is at the list of European Physical Society (EPS) sponsored conferences.

The Invited lectures and 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 Contributed papers is limited and each is supposed to present an original work with sufficient amount of scientific information. The Scientific and Organizing Committees believe that this conference manages to maintain the high scientific level of contributed papers and invited speakers in accordance with SPIG's long tradition.

The Editors would like to thank the members of the Scientific and Advisory Committees of SPIG 2006 for their efforts in proposing the invited lectures and progress reports, review of the contributed papers and selection of 12 papers for the oral presentation. We acknowledge the EPS sponsorships granted through East West Task Force scheme. Also, we are grateful for the support of our sponsors Kryooprema d.o.o. and EUnet d.o.o. Especially we acknowledge the support of all members of the Organizing Committee who contributed a lot to the preparing and running of the conference.

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. The Editors apologize for all mistakes that emerged from the software problems in the process of printing.

Finally we would like to thank all the invited speakers and the participants for taking part in this year's SPIG, to wish them to have a pleasant stay in Kopaonik, and to gain additional momentum and ideas for the future work.

Belgrade, August, 2006

Editors

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# **SPIG 2006**

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  - 1.2. Heavy Particle Collisions
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# SPIG 2006

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# Differential Cross Section for Elastic Electron Scattering by In Atom

M. Pardońska, S. Milisavljević, V. Pejčev,<sup>1</sup> D. Šević, D. M. Filipović,<sup>2</sup>  
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**Abstract.** We report a result of relative differential cross section (DCS) for elastic electron scattering by indium atom at 40eV incident electron energy ( $E_0$ ). This measurement was performed at scattering angles ( $\theta$ ) between  $10^\circ$  and  $150^\circ$ . Our results are compared with corresponding theoretical data.

**Keywords:** Indium, cross section, elastic scattering.

**PACS:** 34.80.Bm

## INTRODUCTION

Indium is a rare and scattered, soft, malleable, silver-white metallic element ( $Z=49$ ) chemically similar to aluminum or gallium but looks more like zinc (zinc ores are also the primary source of this metal). Its current primary application is to form transparent electrodes from Indium tin oxide in liquid crystal displays. Indium, as indium phosphide is used to make photovoltaic devices (devices that transform light energy into electricity) [1], semi-conductors, high-speed transistors, specialized solders and metal alloys. Indium alloys have been used in control rods for nuclear reactors.

Experimental results of elastic scattering of electrons by indium have not been investigated in recent years. The theoretical results were obtained by Kelemen in terms of a model of phenomenological complex potential with allowance for spin-orbit interaction. A few data sets were calculated and compared to experimental results.

## EXPERIMENT

Electron spectrometer ESMA used in this experiment is designed for crossed electron atom beam measurements in which an atomic beam was perpendicularly crossed by monoenergetic electron beam and it has been described earlier [2,3].

Indium vapour beam has been produced by heating oven crucible containing In metal by two separate heaters. The background pressure was of the order of  $10^{-4}$  Pa and the oven temperature was between  $950^\circ$  and  $1000^\circ$  C. A new design of the oven was introduced in order to achieve higher temperatures than those needed for previously investigated metals Ca [2] or Mg [3]. The oven was made more compact. Water cooling of the oven shield together with thermal insulation by ceramics protected the channel electron multiplier from a rise in temperature.

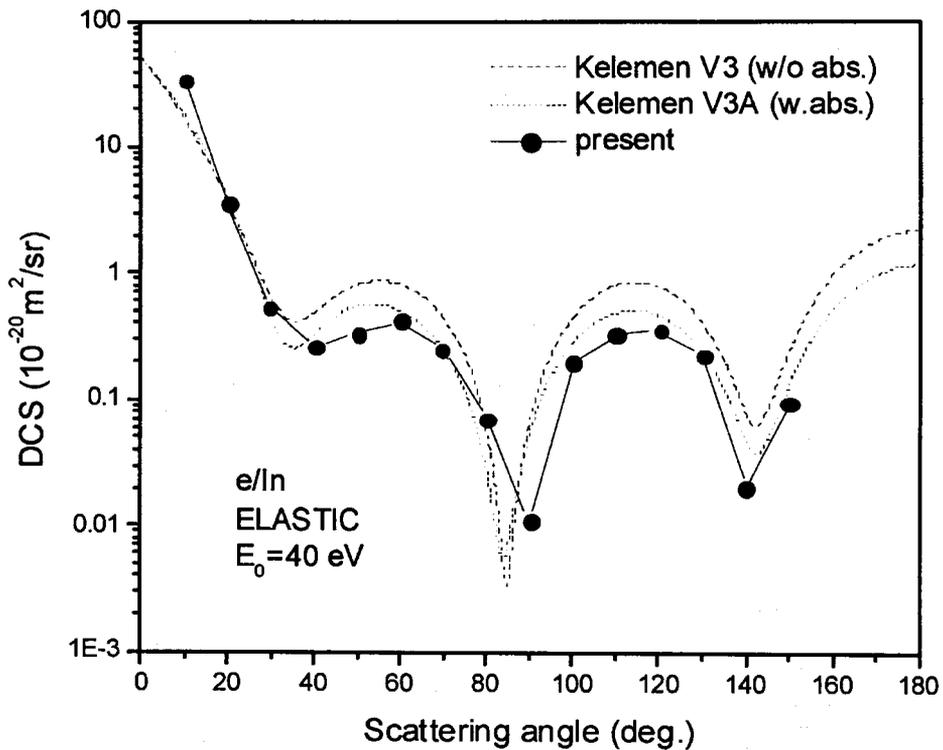
Relative DCSs for the elastic scattering were obtained by direct angular distribution measurements. For a given incident energy  $E_0$ , the position of the analyzer was changed from  $10^\circ$  to  $150^\circ$ . The scattered electrons are energy analyzed by the hemispherical selector, fitted with the system of electrostatic lenses, and are detected by a single-channel electron multiplier. Thus the scattered-electron intensity was directly measured and then was corrected using the effective path-length correction factor according to the approach of Brinkman and Trajmar [4]. The effective path-length correction factor for Indium is presented in Table 1. Relative DCS were normalized by forward scattering function [5] of the generalized oscillators strengths of resonant  $6s^2 S$  state (3.025 eV) of Indium.

**TABLE 1. Effective path-length correction factor.**

Angle (deg.)	Correction factor
10	0.83419
20	0.86006
30	0.89715
40	0.92895
50	0.95396
60	0.97488
70	0.99059
80	0.99705
90	1
100	0.99705
110	0.99059
120	0.97488
130	0.95396
140	0.92895
150	0.89715

## RESULTS AND DISCUSSION

Our experimental result of the relative cross section for elastic electron scattering by In atom at  $E_0 = 40\text{eV}$  incident electron energy is presented in Fig.1, together with two different calculations by Kelemen at the same energy. Our result is normalized at scattering angle of  $20^\circ$  to the differential cross section in the phenomenological optical approximation of potentials (SEPAS).



**FIGURE 1.** Differential cross section for elastic electron scattering by In atom at 40eV impact energy.

To describe polarization effects, the optical potential (OP) is used by Kelemen et al. [6]. A complex phenomenological OP with inclusion of absorption was used for the calculation:

$$V_{opt}^{+(-)}(r, E) = V_R^{+(-)}(r, E) + iV_a(r, E)$$

the SEPASo-approximation (V3A). The calculation with no inclusion of absorption, when only the real part of OP is taken

$$V_R^{+(-)}(r, E) = V_s(r) + V_e(r, E) + V_p(r) + V_{so}^{+(-)}$$

will be called the SEPSO-approximation (V3). The comparison of our measurements with theoretical dates shows that good agreement with results in SEPASo approximations. Agreement with results in SEPSO-approximation is a little different. Our results are lower with respect to those obtained by using the SEPSO-approximation.

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