INTEGRATED CROSS SECTIONS FOR ELECTRON SCATTERING BY MERCURY

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Utilising cross-beam technique relative differential cross sections $\sigma(\theta)$ for both elastic and inelastic (6^1P_1) scattering of electrons by Hg-atoms have been determined experimentally in intermediate energy region from 10 eV to 100 eV in the angular range from 2° (10° for elastic) up to 150°. In addition the 6^3P_1, 7^1S_1 and 7^1P_1 excitation $\sigma(\theta)$ are determined at 60 eV. The $\sigma(\theta)$ are normalised to the optical oscillator strength f_o for the 6^1S_1 - 6^1P_1 transition.

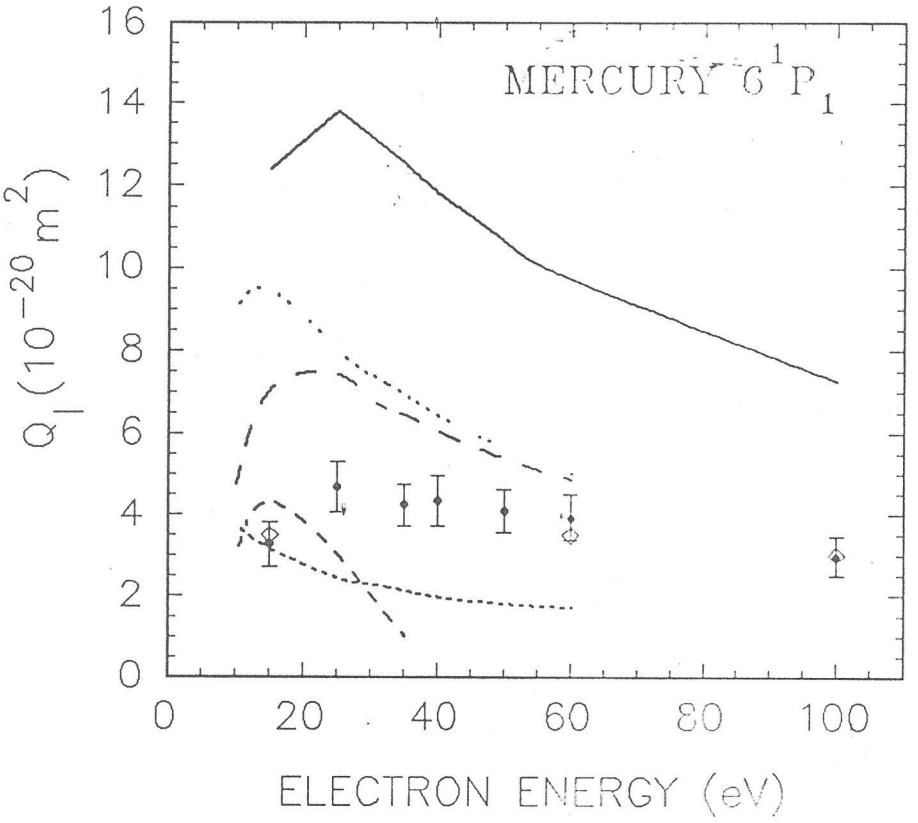
Integrated cross sections are obtained by extrapolating $\sigma(\theta)$ to 0° and 180° and integrating over solid angle. Integral cross sections Q_I are defined as

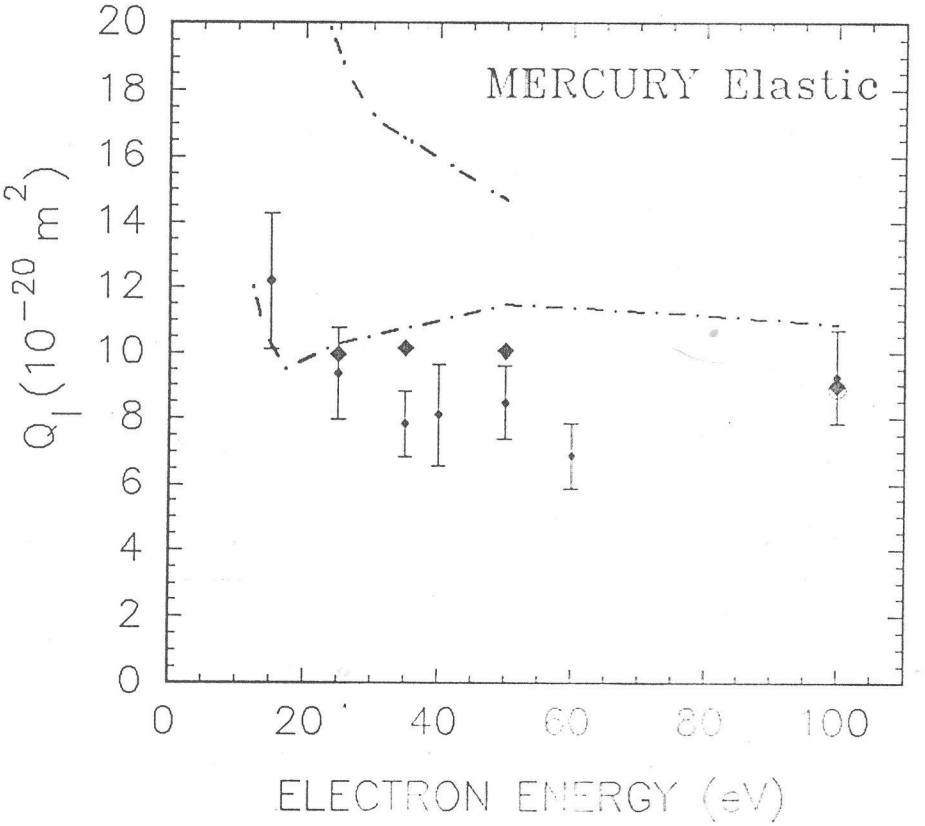
$$Q_I = 2\pi \int_o^\pi \sigma(\theta) \sin\theta \, d\theta$$

and momentum transfer Q_M (n=1) and viscosity Q_V (n=2) cross sections are defined as

$$Q_{M(V)} = 2\pi \int_o^\pi \sigma(\theta) \left[1 - \left(1 - \frac{\Delta E}{E}\right)^{n-1/2} \cos^n\theta\right] \sin\theta \, d\theta$$

where ΔE is energy loss and E is impact energy. Absolute errors are determined as a square root of sum of squared contributing errors (statistical, uncertainty due to energy and angular scales, corrections due effective path length, normalisation to f_o, intensity ratio measurements for the $\sigma(\theta)$ other then 6^1P_1, extrapolation and numerical errors). The mean error for the Q_I is 15% for the elastic scattering, 14% for the 6^1P_1 excitation and 19% for the other excitation processes. The integral cross sections are compared with available experimental and theoretical data. Unfortunately, independent optical excitation functions for the 6^1P_1 do not exist.


MERCURY 6^1P_1
$Q_I(10^{-20}m^2)$
0
2
4
6
8
10
12
14
16
0
20
40
60
80
100
ELECTRON ENERGY (eV)


MERCURY Elastic
$Q_I(10^{-20}m^2)$
0
2
4
6
8
10
12
14
16
18
20
0
20
40
60
80
100
ELECTRON ENERGY (eV)

Integral cross sections for a) the 6^1P_1 state b) elastic scattering. Present measurements are denoted by • with absolute error indicated, calculations: ... and __ __ , McConnell and Moiseiwitsch (1968) Born and Ochkur approximation, respectively; --- , Tripathi *et al* (1969); – – , Kieffer (1975) from Rockwood (1973); -•·- , McEachran and Stauffer (1987); ___ , Srivastava *et al* (1992b); -•--• , Fritsche and Kroner (1992); experiments : ♦ , Holtkamp *et al* (1987); ◊ , Peitzmann and Kessler (1990a) and o , Peitzmann and Kessler (1990b).

ReferencesČ

Fritsche L and Kroner C 1992 private communication

Holtkamp G, Jost K, Peitzmann F J and Kessler J 1987 *J.Phys.B:Atom.Molec.Phys.* **20** 4543

Kieffer L J 1975 *Bibliography of Low Energy Electron and Photon Cross Section Data* NBS Special Pub.426

McConnell J C and Moiseiwitsch B L 1968 *J.Phys.B:Atom.Molec.Opt.Phys.* **1** 406

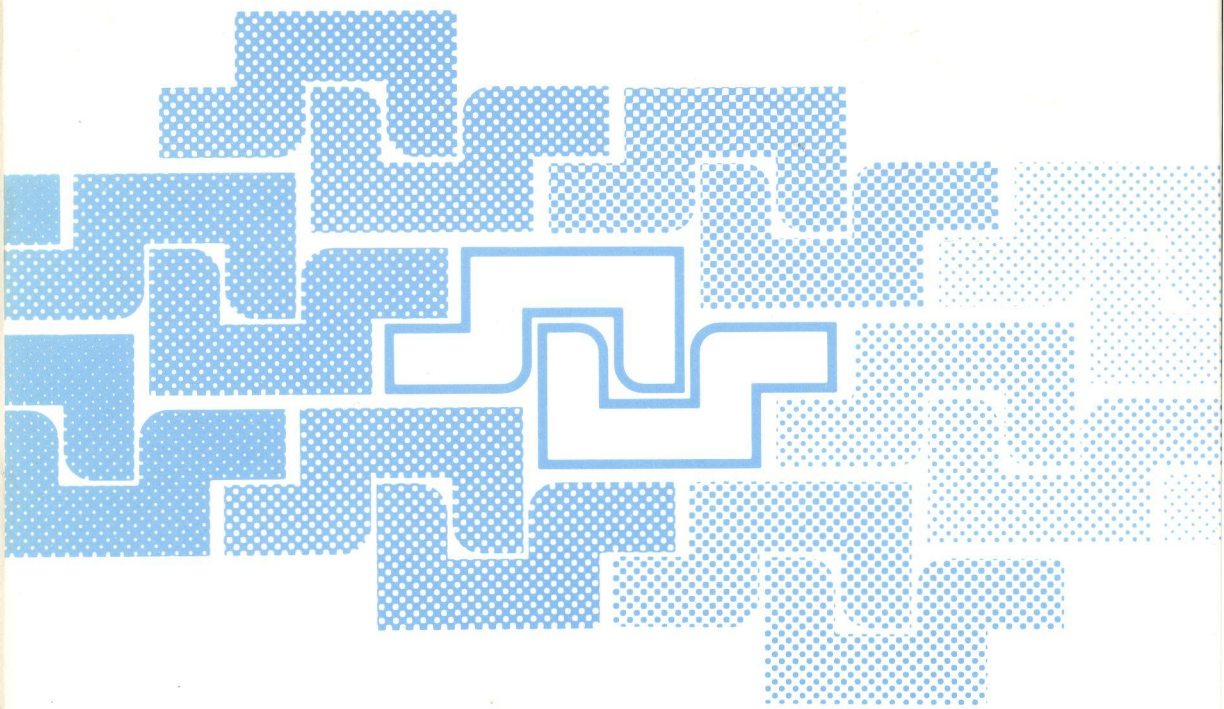
McEachran R P and Stauffer A D 1987 *J.Phys.B:At.Mol.Phys.* **20** 5517

Peitzmann F J and Kessler J 1990a *J.Phys.B:At.Mol.Opt.Phys.* **23** 2629

Peitzmann F J and Kessler J 1990b *J.Phys.B:At.Mol.Opt.Phys.* **23** 4005

Rockwood S D 1973 *Phys.Rev.A* **8** 2348

Tripathi A N, Mathur K C and Joshi S K 1969 *J.Phys.B:Atom.Molec.Phys.* **2** 878



Topics in Atomic and Nuclear Collisions

Edited by

B. Remaud

A. Calboreanu and

V. Zoran

NATO ASI Series

Series B: Physics Vol. 321

Proceedings of a NATO Advanced Study Institute on
Topics in Atomic and Nuclear Collisions,
held August 31–September 11, 1992,
in Predeal, Romania

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Library of Congress Cataloging-in-Publication Data

Topics in atomic and nuclear collisions / edited by B. Remaud, A. Calboreanu, V. Zoran.
p. cm. -- (NATO ASI series. Series B, Physics ; v. 321)
"Published in cooperation with NATO Scientific Affairs Division."
"Proceedings of a NATO Advanced Study Institute on Topics in Atomic and Nuclear Collisions, held August 31-September 11, 1992, in Predeal, Romania"--T.p. verso.
Includes bibliographical references and index.
ISBN 0-306-44662-6
1. Collisions (Nuclear physics)--Congresses. 2. Nuclear reactions--Congresses. 3. Nuclear structure--Congresses. I. Remaud, Bernard. II. Calboreanu, A. (Alexandru) III. Zoran, Valeriu. IV. North Atlantic Treaty Organization. Scientific Affairs Division. V. NATO Advanced Study Institute on Topics in Atomic and Nuclear Collisions (1992 : Predeal, Braşov, Romania) VI. Series.
QC794.6.C6T68 1994
539.7'57--dc20 93-50821
CIP

ISBN 0-306-44662-6

PREFACE

The ASI 'Topics in Atomic and Nuclear Collisions' was organized in Predeal from August 31 to September 11. It brought together people with a broad interest in Atomic and Nuclear Physics from several research institutes and universities in Romania and 16 other countries.

The school continues a tradition that started on a small scale back in 1968, focussing mainly on current problems in nuclear physics. Though the organizing of this edition started very late and in very uncertain economic and financial conditions, it turned out to be the largest meeting of this type ever organized in Romania, both in topics and participation.

There were many applicants for participation and grants, considerably more than could be handled. The selection made by the local organizing committee was based on the following criteria: a proper balance of atomic and nuclear physicists, a broad representation of people from Research Institutes and Universities, a balanced participation with respect to age, sex, nationality and observance of ASI requirements. So, finally the list included 16 lecturers and 76 ASI students (participants). 12 lecturers came from NATO countries. The distribution of participants was as follows: 29 from NATO countries, 33 from the host country (Romania) and 14 from other countries. The school was honoured by the presence of 8 distinguished scientists from the US. Finally, due to a massive interest raised by the school, an extra number of participants (about 40 mostly Romanians, but also a few from Ukraine, Russia and Moldova), were allowed to attend as observers.

One should also add that the term 'student' is not strict; more appropriate is that of 'participant', as among them were many notorious scientists, people of great prestige who delivered full length lectures of high standard. In fact many participants had the opportunity to present short (15') contributions in seminars held sometimes

in parallel with some very specialised lectures. These contributions are collected and will be published in a dedicated issue of 'Romanian Journal of Physics' - (vol.38, no.4, 5;1993).

The subject of the school included phenomena that take place over a huge energy scale, spanning more than 15 orders of magnitude. In spite of their diversity these phenomena share a broad unifying ground and points of contact. Several speakers presented similar approaches based on new developments of the S-Matrix theory, semi-classical or full relativistic treatment. As an example the quantum defect, threshold phenomena and quasi-resonant processes that have been noticed in electron-atom collisions, in low energy nuclear physics, or even in proton-antiproton collision, may be treated within the R-Matrix theory originally developed in nuclear physics by Wigner.

Many lecturers reported up-to-date information on specific phenomena that accompany nucleus-nucleus collisions at energies from Coulomb barrier up to a few hundred MeV/A, or more. They referred to the formation and decay of hot nuclei, the limits of equilibrium, partial fusion, friction and collective flow, revealing new values and meanings for many quantities of interest such as nuclear temperature, compressibility, particle emission multiplicities and correlations. Such data have been inferred from recent experiments at GANIL, Texas A&M University Cyclotron Laboratory, or Darmstadt.

Theoretical approaches were presented on the dynamics of these reactions based on various transport equations and models such as Vlasov-Uehling-Uhlenbeck or the quantum molecular dynamics including realistic nuclear forces determined by the Brueckner G-Matrix. Further refinements, including relativistic generalization, super-dense nuclear matter and Nuclear Equation of State were also discussed by a number of lecturers. Other presentations formulated unified approaches based on time dependent sets of master equations in which a reaction is visualised as a re-arrangement of nucleons in the states of a mean field due to individual collisions and residual interactions until equilibrium is reached. Suggestions for new experiments were made bearing in mind the new facilities existing in some laboratories.

Atomic physics lectures revealed new and fruitful directions of research by making use of the new tools such as particle accelerators, highly charged ion sources and powerful lasers. The new techniques permit investigations of electronic properties of individual atoms, or of matter in bulk either crystalline, or amorphous. Along these lines, detailed data were reported on secondary particle emission and on electron capture in the ion bombardment of surfaces. Other contributions dealt with atoms

in very intense electromagnetic fields. Multi-ionization is possible as it has been demonstrated experimentally during the last decade, with a very large number of photons absorbed, even exceeding the ionization limits.

An atomic ionization stabilization is, however predicted in very intense laser fields. The theory also predicts new exotic shapes of atoms with the electrons raised to high magnetic moment m states and strong linear polarization of emitted photons.

The impetus on atomic physics of the new X-ray facilities, the synchrotron radiation and the X-ray lasers was emphasized. New results on the X-ray interaction with surfaces, or with individual atoms were presented. One particular topic of interest at the meeting, that will capture the attention for some time is photo-ionization.

Much appreciated was a lecture on atom-atom collision, nicely illustrated with a video-clip, modeling various scenarios for atom-cluster dynamics.

Finally a special mention should be made of those contributions that focused on new ideas and concepts. One of these contributions refers to nuclear Tcherenkov radiation, i.e. quanta, or even pions, emitted when a nucleon penetrates and moves in a nucleus as in a refractive dielectric medium. Predictions of energy windows where gamma, or pion radiation are expected have been made and further experiments may confirm the validity of these ideas.

A second interesting contribution dealt with the already classical e-e puzzle, in which the existence of 'quadronium' [2(e-e)] was inferred as a possible explanation for the sharp positron lines observed in U-Ta high energy collision. The debate remains open until a clear phenomenological approach becomes familiar.

New experimental methods have emerged in astrophysics with the purpose of recording signals from space as cosmic rays, gamma and X-rays. One complex project is being implemented in Karlsruhe as a German-Romanian cooperation programme and it was presented at the school.

This recitation of facts is meant to stress that the ASI meeting in Predeal, the first ever organized in a post-communist country, unconceivable a few years earlier, enjoyed indeed a large interest and it was a major event in Romania. It was covered by various media such as press, radio and television.

Scientifically the school organisers intended to give a unitary, if not a unifying view of an extremely large field with applications ranging from astrophysics to solid state, sharing collisions as a common tool and method. We believe such meetings are useful from time to time, as an intermedium between very specialised workshops and broad interest conferences.

Besides the purely scientific goal, the ASI school offered a possibility for the local

organizers and science managers to exchange some views about the ways and means in which science should evolve in a country such as Romania, confronted with a new environment: a new political development, an economy in transition, an intensified competition. Such panel discussions stressed the role of international ties and lobbying for science in the political circles, combined with an accurate evaluation of the scientific output.

The Organizing Committee acknowledges the helpful cooperation of the Institute of Atomic Physics in extending its facilities for the smooth running of the school and for allowing some of its qualified personnel to serve in various offices during the school. We also express our gratitude to various institutions who offered their financial or material support to the school: the CNRS-France, The American Physical Society, The German Physical Society and International Bureau-Karlsruhe, the 'Soros'-Foundation. Above all we are grateful to the Scientific Affairs Division of NATO and to all persons involved in granting the Predeal Summer School the statute of an ASI meeting. Without this help the organizing of the 1992 school would not have been possible.

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Alexandru Calboreanu