29th Summer School and International Symposium on the Physics of Ionized Gases

Aug. 28 - Sep. 1, 2018, Belgrade, Serbia

CONTRIBUTED PAPERS

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ABSTRACTS OF INVITED LECTURES, TOPICAL INVITED LECTURES, PROGRESS REPORTS AND WORKSHOP LECTURES

Editors:
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PREFACE

This publication contains the contributed papers and abstracts of Invited Lectures, Topical Invited Lectures, Progress Reports and Workshop Lectures that will be presented at the International Symposium on the Physics of Ionized Gases 2018. This is the 29th of a series of events which reflect the progress in this challenging field of science. The event is organized by the Vinča Institute of Nuclear Sciences in Belgrade and Serbian Academy of Sciences and Arts, with the support of the Ministry of Education, Science and Technological Development of the Republic of Serbia.

The aim of this book is to present new results in the fundamental and frontier theories and technology in the area of general plasma physics (including astrophysical and fusion plasmas), atomic collision processes and particle and laser beam interactions with solids. Also, the presented results and lectures of the 3rd Workshop on X-ray and VUV interaction with Biomolecules in Gas Phase - XiBiGP are also included.

Herein, the Editors would like to thank the authors and reviewers for their support of this event and to wish all participants a pleasant and productive stay in Belgrade. We are grateful to the Serbian Academy of Sciences and Arts for their long term commitment to support this event as well as the Serbian Ministry of Education, Science and Technological Development for their continuing help. We also acknowledge the support of the open access journal "Atom"

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HIGH RESOLUTION AUTOIONIZING STATES OF KRYPTON IN KINETIC ENERGY REGION 8 – 35 eV

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Abstract. High resolution electron spectroscopy has been used to investigate the spectra of ejected electrons of krypton at 90° ejection angle in the kinetic energy region 7.8-36 eV at high incident electron energies of 505 and 2019 eV. The energies of the observed features have been compared with previous experiments and a good agreement has been found.

1. INTRODUCTION

The measurement of the ejected electron spectra produced by the decay either of an excited state of a neutral atom to the ground or excited state of the singly charged ion (autoionizing transitions) or of an inner shell ionized atom to the states of the doubly charge ion (Auger transition) is one of the most suited methods to reconstruct the electronic structure of an atom. In this work, we present high resolution ejected electron spectra of krypton in the region of the autoionizing transitions between 7.8 and 24 eV and in the low energy MNN Auger region between 24 and 35 eV and compare them with previous electron impact studies.

Kr ejected electron spectra have been reported by Siegbahn *et al* (1971) [1] and Tweed *et al* (1976) [2], while Srivastava and Trajmar (1978) [3] and Baxter et al (1982) [4] measured electron energy loss spectra. The Kr MNN Auger spectra have been studied by Werme *et al* (1972) [5]. Kikas *et al* (1996) [6] made an extensive investigation of Kr^+ satellite spectrum by photoelectron spectroscopy.

2. EXPERIMENT

The apparatus used in the present measurements has been described previously [7], thus only a brief report is presented here. It consists of a non-monochromatic electron gun (10-2500 eV) which can rotate from 10° to 130° around the analyzer axis, and a high - resolution hemispherical analyzer with a

mean radius of 125 mm. The ejected electrons are detected with seven channeltrons. A 20 mm long platinum-iridium non-biased needle with internal diameter of 0.5 mm has been used to produce an atomic beam in the perpendicular direction to the scattering plane.

The background pressure in the vacuum chamber was $6x10^{-8}$ mbar, while the working pressure with krypton gas was $2x10^{-6}$ mbar. With an electron current of about 10^{-6} A the typical accumulation time for most of the spectra was 60 min with energy step of 0.020 or 0.050 eV per channel. The transmission was not uniform in low energy part and all spectra are presented with subtracted background without any further normalization of the data. The calibration of the kinetic energy scale was achieved using the line at 11.72 eV from the Ar [$3s3p^6 3d(^1D)$] excited state (27.48 eV excitation energy). The scale of the incident energies was calibrated using the elastic channel. For higher energies until 2000 eV, the fit made below 200 eV was applied. The FWHM of the elastic peak was roughly 0.80 eV.

3. RESULTS AND DISCUSSION

Figure 1 shows two high resolution ejected electron spectra obtained at 505 and 2019 eV at 90°. The spectrum at 2019 eV is obtained with energy step of 0.020 eV at lower statistics, while the spectrum at 505 eV with energy step of 0.050 eV has been recorded with better statistics. Despite this both spectra display the same number of features produced by the decay of single and double excited states with $4s4p^6nl$ and $4s^24p^4nln'l'$configurations to Kr^+ states. The spectrum can be divided in two regions: one due to the decay of the $4s4p^6nl$ singly excited states converging to the 4s ionization threshold and another one above this threshold where the decay of neutral doubly excited and satellite states contribute. In the first region the most pronounced features are due to the decay of the $5s(^3S_1)$, $4d(^1D_1)$ and $5d(^1D_1)$ states at 9.44 eV, 11.58 eV and 12.48 eV respectively. Above the 4s ionization threshold, the prominent features are due to the $4s^24p^4$ excited ionic states: the $(^3P)5s\ ^2P_{3/2}$, $(^1D)5s\ ^2D_{5/2}$ and $(^3P)4d\ ^2D_{5/2}$ at 28.70 eV, 29.86 eV and 31.06 eV, respectively. A good agreement among measurements is achieved, but still large number of features stayed unassigned. A detailed analysis will be presented at the conference.

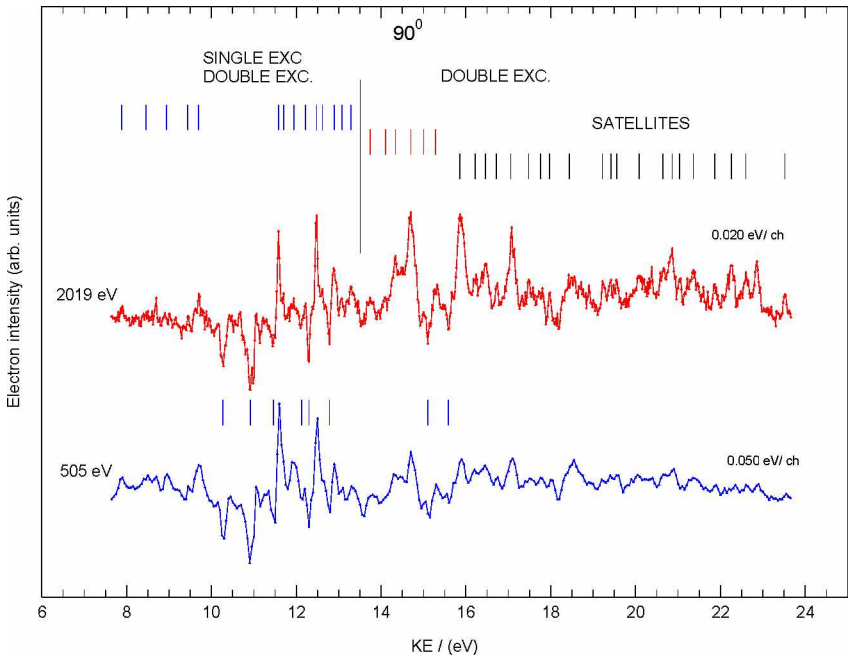

Figure 1. Ejected electron spectra obtained between 7.8 and 24 eV. The energies of the peaks are indicated by short bars on the top spectrum, while the ones of the dips by the bars between two spectra. The vertical line shows the limit of the $4s4p^6nl$ series.

Figure 2 shows low energy part of the Kr MNN Auger spectra with features labeled from 1 to 20 measured at 505 and 2019 eV incident energy and angle of 90°. The present spectra well compare with the one by Werme *et al* (1972) [6], although a different approach in calibration procedure leads to a systematic difference in energies of about 0.150-0.170 eV. Both Auger transitions and their satellites contribute to the observed spectra. The first two features at 24.16 and 25.42 eV are due to transitions from the initial vacancies in the $3d_{5/2,3/2}$ (M_5 and M_4) with the final $4s^24p^3(^2P)6s\ ^1P_1$ state, while the peaks labeled 12 and 16 at 31.06 and 32.30 eV correspond to the $4s^04p^6\ ^1S_0$ final state. A detailed analysis of the spectra will be presented at the conference.

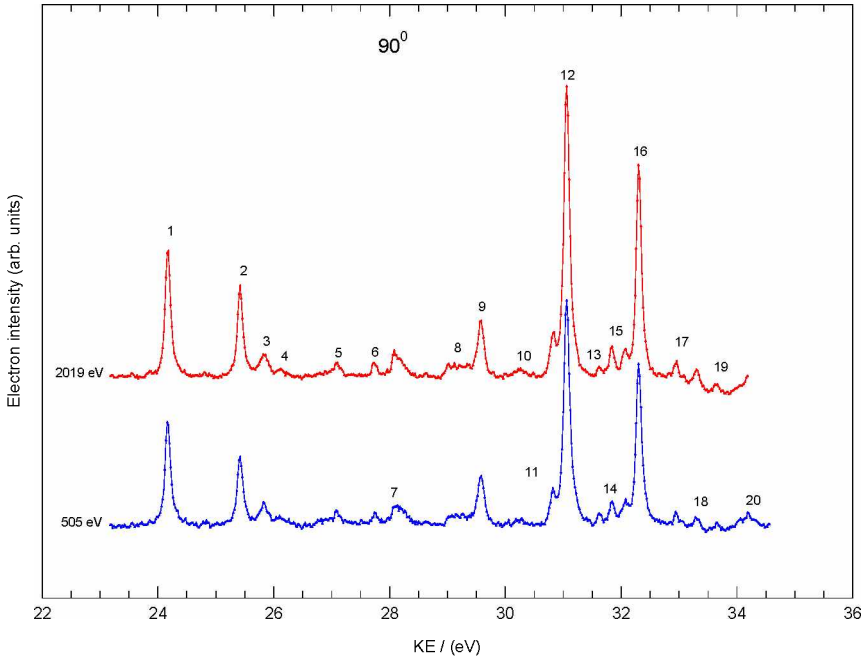

Figure 2. Low energy part of the $M_{4,5}NN$ Auger krypton spectra.

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REFERENCES

[1] K. Siegbahn *et al, ESCA Applied to free Molecules* p. 153, (North-Holland, Amsterdam, 1971).
[2] R. J. Tweed, F. Gelebart and J. Peresse, J. Phys. B 9, 2643 (1976).
[3] S. K. Srivastava and S. Trajmar, J. Phys. B 11, 3433 (1978).
[4] J. A. Baxter, P. Mitchell, J. Comer, J. Phys. B 15, 1105 (1982).
[5] L. O. Werme, T. Bergmark and K. Siegbahn, Phys. Scripta 6, 141 (1972).
[6] A. Kikas, S. J. Osborne, A. Ausmees, S. Svensson, O. P. Sairanen, S. Aksela, J. El. Spec. Rel. Phenom. 77, 241 (1966).
[7] J. J. Jureta, B. P. Marinković and L. Avaldi, Eur. Phys. J. D 70, 199 (2016).

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