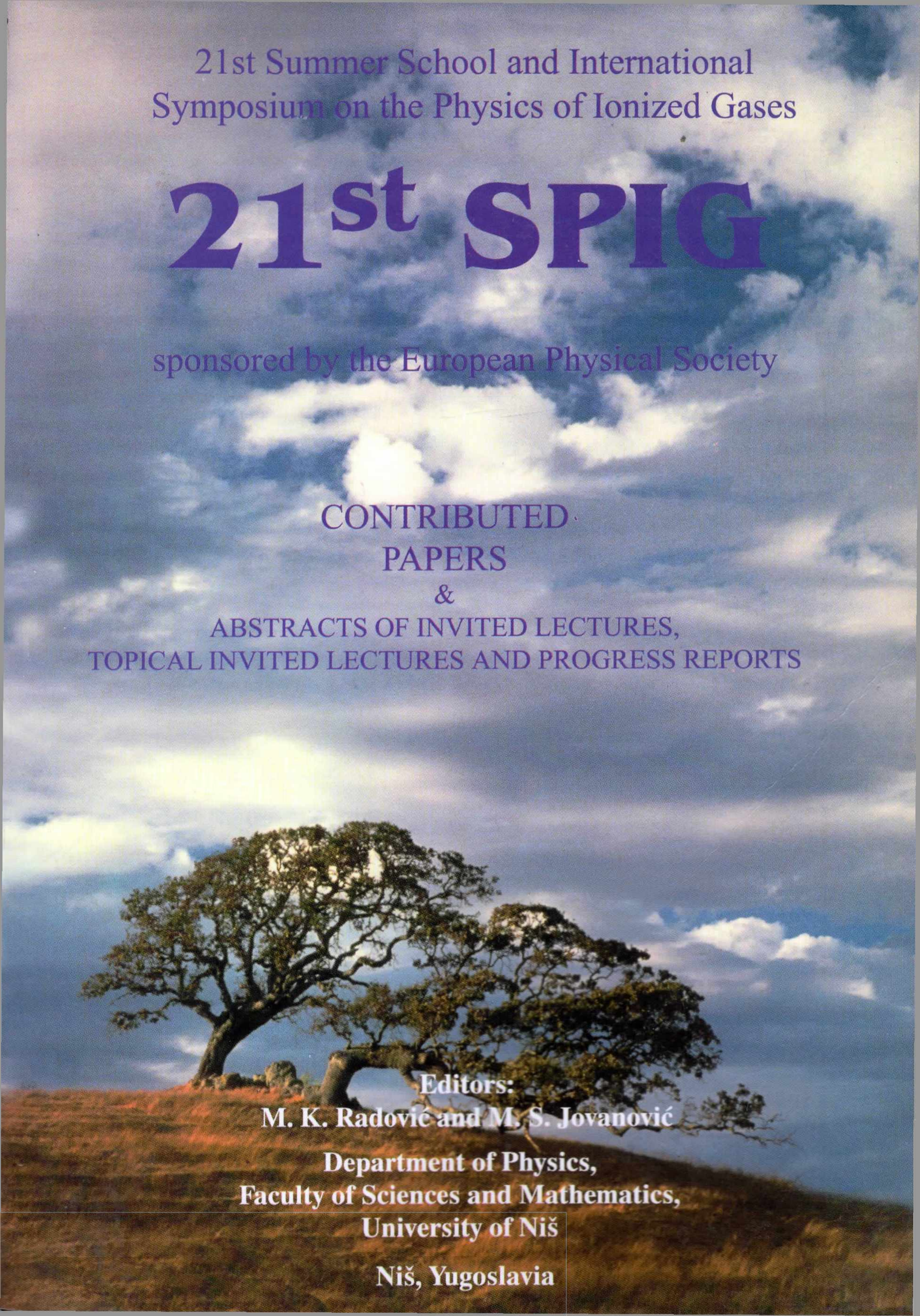

21st Summer School and International
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DECOMPOSITION OF LINES IN ELECTRON AUTOIONIZING SPECTRA OF Zn

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Electron spectroscopy provides observation of discrete lines above the ionization limit. Particularly, scattered electron measurement is a powerful method to investigate excitation and decay of atomic autoionizing states, lying in this region. For this purpose, the ejected-electron spectra have been used [1]. In our laboratory we have used the energy-loss electron spectroscopy to study autoionization processes in Cd [2]. In this work, the same method is applied in the case of Zn.

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Optical autoionizing level measurements in the energy range of interest (>10 *eV*) apply vacuum UV [4] or optogalvanic technique [5]. Application of the UV technique is practically useless for optically forbidden transition measurements. In opposite, conventional electron spectroscopy overlaps a broad incident electron energy (E_0) region, below and above the first ionization limit. Although the energy resolution in the light optics is superior, we utilize electron energy-loss spectroscopy at different scattering angles (θ) to study "optically forbidden" autoionizing levels of Zn.

This experiment is more difficult than in the case of Cd due to the smallness of the intensities. Only the energy-loss spectra of Zn at $E_0=20$ *eV* ($\theta=10°$ and 90°) and $E_0=40$ *eV* ($\theta=10$) are available [6]. Although the line widths are not small, line separation is small, so whole attention in our work was given to the decomposition and shapes of these lines.

2. EXPERIMENTAL

The electron-impact spectrometer, described in detail elsewhere [7], was used in the energy-loss mode of operation. Briefly, a monoenergetic electron beam crosses a beam of Zn atoms perpendicularly. The electrons scattered at the angle θ, being accepted by the analyzer, electrostatic hemispherical selector and detected by the single channel electron multiplier. The energy resolution was about 120 *meV* due to compromise with very small intensities. We have used titanium oven (resistant to high temperature Zn-vapor) heated by coaxial heaters. High purity (99.9%) Zn was firstly heated up to 800 *K*, but working temperatures were between 670 and 750 *K*. This procedure was necessary because the features in vicinity of 11.6 *eV* were screened by a feature due to double scattering of incident electrons after excitation of the 4p ($^1P_1$) resonant state at 5.8 *eV*. We decreased the temperature from 800 *K* to a temperature at which the concentration of Zn atoms was high enough for sufficiently good statistics, but shape of the autoionizing spectrum is independent of the temperature.

3. RESULTS AND DISCUSSION

We have recorded electron energy-loss spectra of Zn at: E_0=20 *eV* (θ=6° and θ=10°), E_0=60 *eV* (θ=4°, θ=6° and θ=10°), E_0=80 *eV* (θ=0°, θ=4° and θ=10°) and E_0=100 *eV* (θ=0°). As an example, the autoionizing spectrum at E_0=80 eV and θ=4° is shown in figure 1. Decomposed lines, assigned according to Mansfield [8], are numbered in the figure and table 1.

Table 1. Autoionizing lines of Zn in the energy region from 11 *eV* and 12 *eV*.

Line No. in fig.1	Energy, *eV*	J	Assignment Term (and purity)
1	11.183	3	$3d^{9}4s^{2}4p(64\%\,{}^{3}F+33\%\,{}^{1}F+3\%\,{}^{3}D)$
2	11.203	4	$3d^{9}4s^{2}4p(100\%\,{}^{3}F)$
3	11.218	1	$3d^{9}4s^{2}4p(92\%\,{}^{3}P+4\%\,{}^{1}P+3\%\,{}^{3}D)$
4	11.387	0	$3d^{9}4s^{2}4p(99.5\%\,{}^{3}P)$
5	11.407	2	$3d^{9}4s^{2}4p(68\%\,{}^{3}F+15\%\,{}^{3}D+15\%\,{}^{1}D+1\%\,{}^{3}P)$
6	11.441	0	$3d^{10}4p^{2}\ (99.8\%\,{}^{1}S)$
7	11.501	3	$3d^{9}4s^{2}4p(64\%\,{}^{3}D+30\%\,{}^{1}F+5\%\,{}^{3}F)$
8	11.583	2	$3d^{9}4s^{2}4p(49\%\,{}^{1}D+30\%\,{}^{3}F+21\%\,{}^{3}D)$
9	11.682	3	$3d^{9}4s^{2}4p(36\%\,{}^{1}D+33\%\,{}^{3}D+31\%\,{}^{3}F)$
10	11.828	1	$3d^{9}4s^{2}4p(73\%\,{}^{3}D+20\%\,{}^{1}P+6\%\,{}^{3}P)+3d^{10}4s4p(0.5\%\,{}^{1}P)$
11	11.875	2	$3d^{9}4s^{2}4p(61\%\,{}^{3}D+36\%\,{}^{1}D+2\%\,{}^{3}P+1\%\,{}^{1}F)$
12	11.892	1	$3d^{9}4s^{2}4p(73\%\,{}^{1}P+24\%\,{}^{3}D+1\%\,{}^{3}P)+3d^{10}4s4p(2\%\,{}^{1}P)$

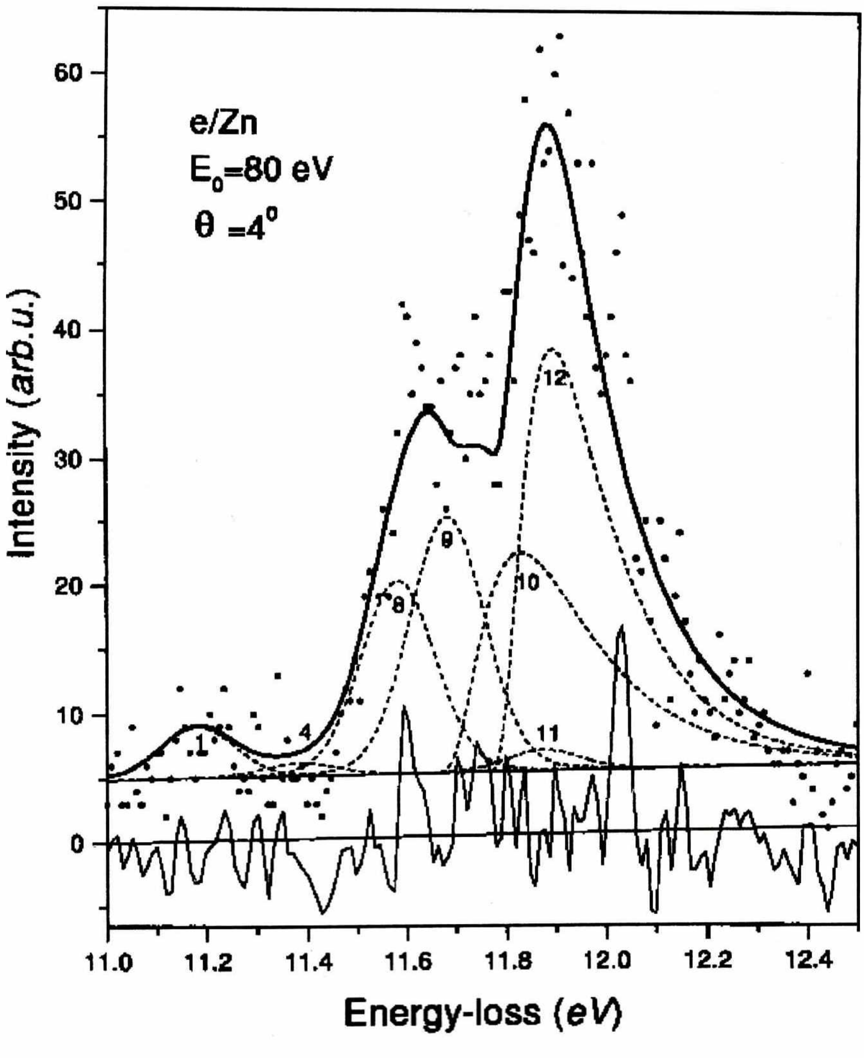

Figure 1. Autoionizing spectrum of Zn, from 11 eV to 12.5 eV incident electron energy.

Electron configuration of Zn in the ground state is (Ar) $3d^{10}4s^2$ ($^1S_0$). The lowest single inner-electron autoionizing states form a group in the energy range from 11 eV to 12.5 *eV*, are assigned as $3d^9\,4s^2(^2D)\,4p$.

Lines 1, 4, 8 and 9 are clearly visible in the spectra at all numbered energies. We decomposed line 2 for E_0=20 eV (θ=10°) and E_0=80 eV (θ=0°). Line 3 is decomposed, as a week feature in the spectrum at E_0=80 eV (θ=0°), recorded with the best statistics. We didn't saw lines 5 and 6 in our spectra. Line 7 was decomposed as a week line in the spectra at E_0=60 *eV* and E_0=80 eV (θ=0°). Line 11 is a week line, between intense lines 10 and 12, decomposed in this work only for E_0=80 eV (θ=4°). Voigt profile was used for drawing all of numbered lines, except 10 and 12. Asymmetric (log-normal) profiles of these two lines enable sufficiently good fit of experimental data, consistent in all of our spectra.

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IN ELECTRON AUTOIONIZING SPECTRA OF Zn

B.Predojević[*], D.Šević, V.Pejčev[#], B.P.Marinković and D.M.Filipović[+]

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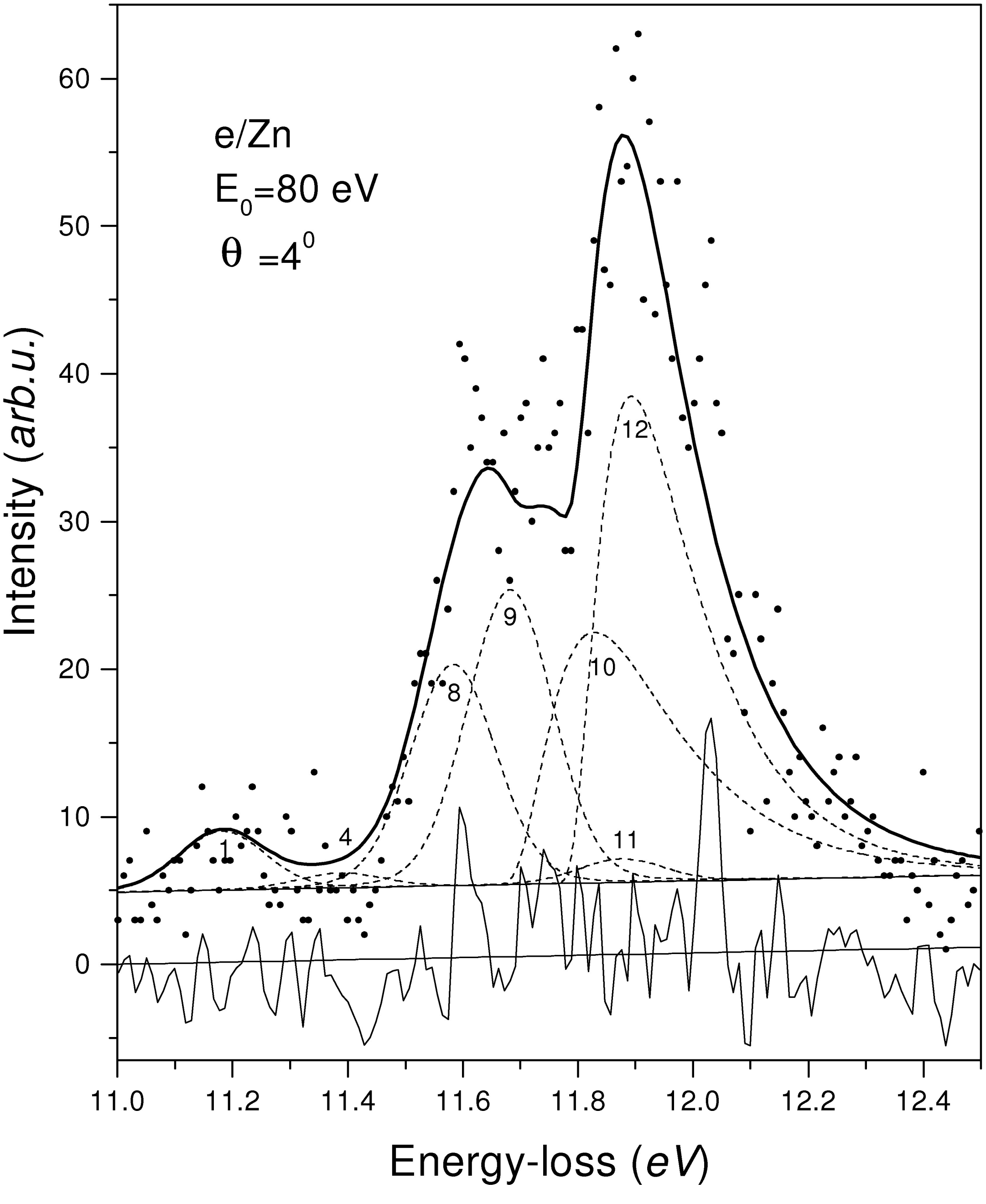

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