Electron Impact Excitation of the 6p7s $^3P_1$ State of Pb Atom at Small Scattering Angles: Generalized Oscillator Strengths

S. Milisavljević, M. Parđovska, D. Šević, V. Pejčev[*], D. M. Filipović[**] and B. P. Marinković

Institute of Physics, P. O. Box 68, 11080 Belgrade, Serbia
[*]*Faculty of Natural Sciences, Radoja Domanovića 12, 34000 Kragujevac, Serbia*
[**]*Faculty of Physics, University of Belgrade, P. O. Box 368, 11001 Belgrade, Serbia*

Abstract. Electron impact excitation of the 6p7s $^3P_1$ state of Pb atom has been experimentally investigated at incident electron energies of E_0 = 10, 20, 40, 60, 80 and 100 eV and small scattering angles up to 10°. Measured angular distributions of the scattered electrons were converted into relative differential cross sections (DCSs) by using the appropriate effective length correction factors. Generalized oscillator strengths (GOSs) for this transition were calculated from the DCS values. The forward scattering function method (FSF) has been used for determination of the absolute GOS and DCS values.

Keywords: Lead, electron excitation, generalized oscillator strengths.
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INTRODUCTION

Lead atom can be regarded as an interesting target from the point of view of studies of electron atom scattering processes. This is a heavy open-shell atom having nuclear charge equal to 82 and thus, electron scattering by this atom should show relativistic effects. Since lead has been identified in different astrophysical objects, solar and stellar spectra as well as in the interstellar medium, electron impact excitation cross sections for Pb atom are very important for astrophysics. Pb lines observed in the solar photosphere and chromosphere and in spectra of other stars have been used for many abundance determinations and for the determination of the chemical composition of these objects.

This paper extends our previous work on Pb [1-3] by providing new scattering data for this atom. Inelastic collision leading to the excitation of 6p7s $^3P_1$ state from the ground state $6p^2$ $^3P_0$ have been studied experimentally at incident electron energies of 10, 20, 40, 60, 80 and 100 eV and scattered electrons were detected over the angular range from 1° to 10°. Here we present generalized oscillator strengths (GOSs) for the $6p^2$ $^3P_0 \rightarrow$ 6p7s $^3P_1$ transition calculated from the measured relative differential cross sections (DCSs) and normalized using the forward scattering function (FSF) method.

EXPERIMENT

The new inelastic scattering data for Pb atom excited to the 6p7s $^3P_1$ state by electron impact are obtained using the same experimental set-up as for the Mg [4] experiments. The experiment was carried out using a crossed electron-atom beam technique in the electron spectrometer "ESMA". A more detailed description of the apparatus and operating conditions has been given elsewhere [3, 4].

Before each measurement the energy loss spectra were obtained to verify the absence of double scattering. Then, angular distribution of scattered electrons was measured at small scattering angles. The position of true zero was determined and checked according to the symmetry of scattering intensities at negative and positive angles between -10° and +10°. Effective path length correction factors [5] for our scattering geometry and experimental conditions converted the measured intensities to relative differential cross sections. In order to put results on an absolute scale, we normalized the relative DCSs as it is described by Felfli and Msezane [6] using the FSF method introduced by Avdonina *et al.* [7]. The FSF curve terminates at optical oscillator strength (OOS) for the 6p7s $^3P_1$ state. We used the OOS value of 0.26 by Biemont *et al.* [8]. Relative DCSs were converted to the generalized oscillator strengths (GOSs) according to formula:

$$GOS(K,E) = \frac{\omega}{2}\frac{k_i}{k_f}K^2 DCS(E,\theta)$$

where ω is the excitation energy, k_i and k_f are the electron momenta before and after the collision and momentum transfer squared is given as:

$$K^2 = 2E\left[2 - \frac{\omega}{E} - 2\sqrt{1-\frac{\omega}{E}}\cos\theta\right]$$

where E is the impact energy. Atomic units have been used. Obtained GOS values were fitted and extrapolated at small values of K^2 obtained from zero scattering angle and normalized to the FSF. Normalization factors obtained in this way were used to obtain absolute DCS values.

RESULTS AND DISCUSSION

An energy loss spectrum of lead at impact energy of 10 eV and at scattering angle of 10° is shown in figure 1. Overall system energy resolution (FWHM) of about 120 meV was maintained in order to observe resonance structure at 4.375 eV. Features observed in the spectrum are assigned according to Moore [9].

Generalized oscillator strengths for the excitation of the 6p7s $^3P_1$ state versus the squared momentum transfer at all energies are shown in figure 2.

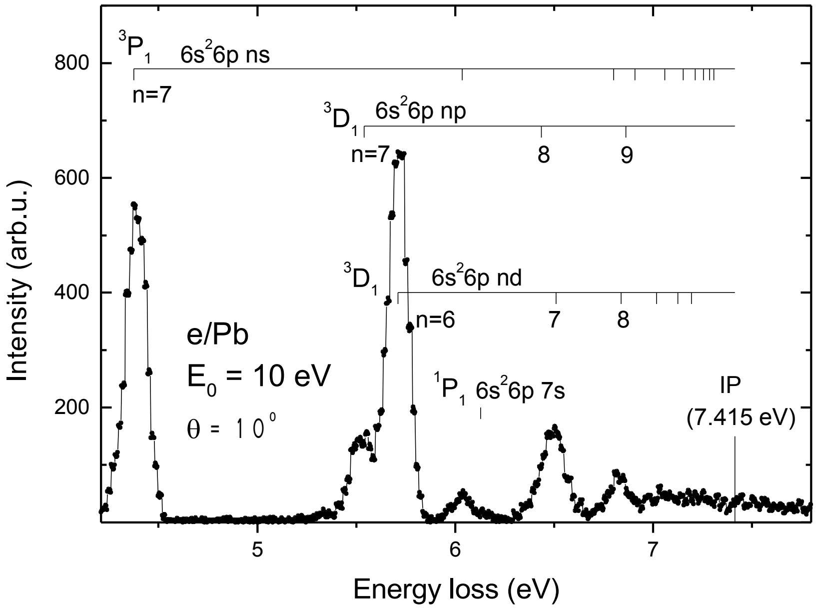

FIGURE 1. Energy loss spectrum of lead at 10 eV electron-impact energy and 10° scattering angle.

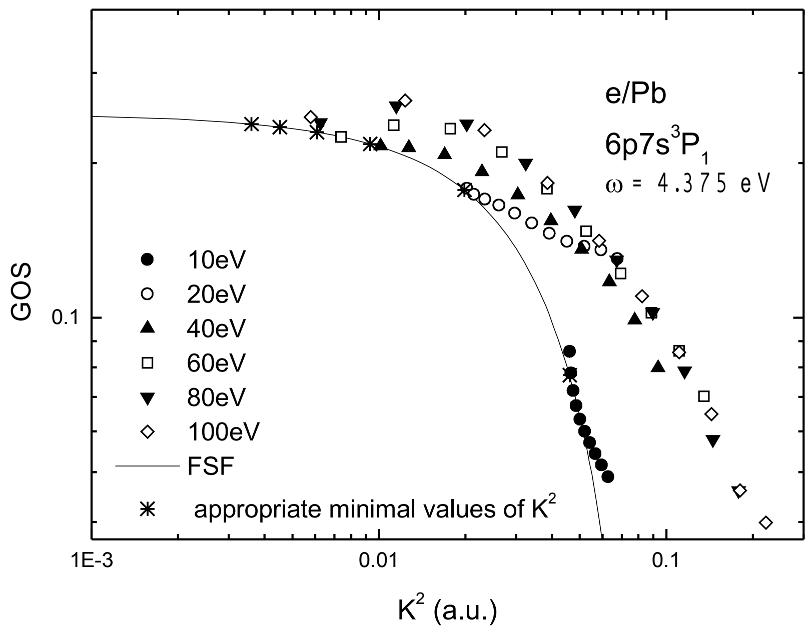

FIGURE 2. Generalized oscillator strengths (GOS) for the 6p7s $^3P_1$ state of lead atom versus momentum transfer squared (K^2) at energies indicated ; *, the appropriate minimal values of K^2; □□ , forward scattering function (FSF) generated using the optical oscillator strength (OOS) value of 0.26 obtained by Biemont *et al*. [8].

The minimal values of squared momentum transfer slide down the forward scattering function curve as the energy decreases, from 0.0036 at 100 eV to 0.0459 at 10 eV and this behavior is predicted by theory [7]. According to the same theory, GOS values should be fitted by straight lines but in our case GOS values do not follow this prediction especially at E > 20 eV. As one can see, normalized GOSs rapidly decline when the electron energy increases. Electron energy of 10 eV is at the limit of validity for this normalization technique, defined as approximately 2.5 times the excitation energy.

Absolute DCS values we will present at the conference.

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