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Elastic electron scattering by lead atom in the energy range from 10 to 100 eV

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Abstract. Electron scattering by lead atom is studied at energies 10, 20, 40, 60, 80 and 100 eV by applying a parameter-free complex optical potential. The real part of the complex optical potential includes the static potential $V_{st}(r)$, the polarization potential $V_{pol}(r)$ that consists of the short-range correlation and long-range polarization effects and $V_{ex}(r,k)$ term consisting of electron exchange interaction which is modeled by assuming the electron charge cloud as a free electron gas. The loss of flux into the inelastic channels is included via a phenomenological absorption potential. Our results are compared with the recent theoretical and experimental measurements.

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Key words: electron scattering, differential scattering cross sections, variable phase approach, complex optical potential

1 Introduction

In our previous work [1-3], we reported results for theoretical investigations on elastic electron collision by Yb, Ca and Mg atoms. Here we continue our study of elastic electron collision with Pb atom. As we know, electron atom collision can be described by many theoretical approaches and that is why it is important to test the various approximations with experimental measurements. At the same time elastic electron scattering is very important in many fields such as physics of stars and plasmas [4].

Below any inelastic scattering thresholds, the scattering of electrons from atoms can be well represented as a potential scattering problem by including the static, polarization and exchange potentials. A simple way to take into account the open inelastic channels within the framework of a potential scattering problem is to use a simple computational

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approach of complex optical potential in which the imaginary part represents the absorption of flux. The more elaborate theories, such as convergent close coupling or R-matrix methods, take into account these additional channels but at the cost of very substantial increase in the complexity of the problem and the computer resources needed .

In the present work, theoretical studies of differential cross sections (DCS) of electron scattering by Pb atom have been carried out at projectile energies of 10, 20, 40, 60, 80 and 100 eV. We have employed a model complex optical potential approach. The real part of the optical potential consists of static potential, the exchange potential incorporated by treating the electron cloud as a free gas, and a polarization potential. The imaginary part of the optical potential represents the absorption potential that takes into account the loss of flux due to all energetically possible inelastic channels. The only experimental parameters required are the first ionization potential and the dipole polarizability of the target atom for the construction of the full optical potential. After generating the full optical potential of the scattering system, we treat it exactly in a partial wave analysis in terms of a set of first-order coupled differential equations for the real and imaginary parts of the complex phase shift functions under the variable phase approach [1-3] and the differential cross sections are calculated.

2 Theory

All the major interactions of electron atom scattering can be represented by a complex, energy dependent, optical potential $V_{opt}(r,k)$ as

$$V_{opt}(r,k)=V_{st}(r)+V_{ex}(r,k)+V_{pol}(r,k)+iV_{abs}(r,k), \tag{1}$$

where $V_{st}(r)$ is the static potential obtained from the DHFS function [5], $V_{ex}(r,k)$ is the exchange potential obtained from FEG model [6], $V_{opt}(r,k)$ is the polarization potential model [7] and $V_{abs}(r,k)$ is the absorption potential [8] that takes into account the loss of flux due to all energetically possible inelastic channels. The parameters used in our calculations are shown in Table 1.

Table 1. Parameters used in the present calculations for electron lead scattering.

Atom	Average dipole polarizability α_d in a_0^3	Ionization potential energy in eV
Pb	45.89	7.42

After generating the full optical potential of a given electron-atom system, we treat exactly in a partial wave analysis by solving the following set of first order coupled different equations for the real x_l and imaginary Im (x_l) parts of the complex phase shift function under the variable phase approach [1-3]

$$\chi_l'(kr)=\frac{-2}{k}[2V_R(r)(A^2-B^2)+2V_{abs}(r)AB], \tag{2}$$

$$\mathrm{Im}\chi_l'(kr)=\frac{-2}{k}[2V_R(r)AB-2V_{abs}(r)(A^2-B^2)], \tag{3}$$