Differential Cross -Section Elastic Scattering Of Electrons By Silver Atoms

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ABSTRACT

The differential cross-section (DCS) was theoretically calculated and measured with constant incident energies ranging from 10 eV to 100eV electron volts as a function of the scattering angle of 10^o-150^o. Dirac's relativistic equation is used to estimate the cross-sections of electron scattering and the spin polarization of electrons scattering from the silver atom. The obtained results are analyzed and compared with theoretical as well as experimental results of other research. The usefulness of this study is limited to obtaining information about scattering.

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1. Introduction

Electron scattering by metal atoms provides useful information to understand their structures and reaction mechanism through cross-sections [1, 2]. The obtained information is of great value in plasma physics and astrophysics radiation, biomedicine,…etc . Silver atom has the highest temperature and electrical conductivity, used a target for electron scattering study. Silver is a precious metal used for many years to make delicate pieces of and coins[3] Particle interactions with silver atoms are important for plasma diagnosis, astrophysics and the development atomic frequency criteria [4, 5] Improvements accuracy of astronomical observations and plasma modeling techniques led to increasing the accuracy of the collision data used to interpret the measurements. In recent years, several studies [6-8] published an estimation the scattering of electron cross-sections by atoms. Tosik et al[9]. both experimental and theoretical measuring the differential cross-sections with electron impact energies of 10, 20,30, 40,50, 60, 80 and 100 eV based on the cross-beam technique and their performance calculations using parameter-free complex optical potentials including spin–orbit interaction. They noted that the experimental and theoretical results are greatly differing and require further investigations. Arnal et al.[10] . studied the electron scattering cross-sections of silver samples with different energies while the effect of spin on the low-energy elastic scattering of gaseous atoms was studied by Fink and Ingram[11]. They used Hartree-Fock possibility of relativity for Slater scattering for solving the Dirac equation excluding incident electron exchange with atomic electrons and polarization using the CPC code for Yates [12]without using polarization and potentiometric with energies greater than 100 MeV and also used a method introduced by Bonham and Strand[13] to solve Dirac equation using empirical capabilities. Jablonski et al. [14] analyzed differential cross sections (DCS) that derived from two potentials Thomas Fermi Dirac (TFD) and Dirac-Hartree-Fock (DHF). The differential cross-sections of the electron by silver atom was calculated using Eikonal approximation with Lenz Jensen potentials [15]. The use of distinct model representations of an incident particle's interaction with an atomic system is controlled by the important need of adopting, if possible, equivalent approximations. This allows for a unified explanation of the scattering process. We use the optical potential (OP) technique to calculate various functional properties, constants, and interaction potentials needed to characterize electron scattering by atoms[16] .In this paper, the differential elastic cross sections of silver atoms at medium and low energies of 10 to 100 eV is calculated and obtained results are compared by previous published experimental and theoretical studies of silver atom.

2. Theoretical approach

Theoretical approach the contraction scattering potential is an important issue the parameters of calculating scattering in which there exist a complex potential such as the optical potential. Consequently, the process of contraction of scattering potential should be study and determine. Basically, the structure of V(r) opt consisting of three words the static V(r)st, exchange V(r)ex, and the correlation polarization potential V(r)copl. The interaction energy between the projectile and target atom is could be acquired by [16].

$$\boldsymbol{VZ_{ie}}\ (\boldsymbol{r})_{\boldsymbol{st}} = \emptyset \qquad (1)$$

Where Z_{ie} is the charge of incident particles where Z_i = -1 for election and Z_i =1 for positron, and $\emptyset$(r) is the electrostatic potential function of the target atom which expressed as the total of the electron cloud's and the nucleus' contributions.

$\emptyset_n r^{`}$ and $\emptyset_e(r)$ respectively

$$\emptyset = \emptyset_{\mathbf{n}} + \emptyset_{\mathbf{e}} \qquad (2)$$

$$\emptyset_{\mathbf{n}}(\mathbf{r}) = \mathbf{e}\left[\frac{1}{\mathbf{r}}\int_0^{\mathbf{r}} 4\pi \mathbf{r}^2\, \rho_{\mathbf{n}}(\mathbf{r}^{`})\mathbf{d}\,\mathbf{r}^{`} + \int_{\mathbf{r}}^{\infty} 4\pi \mathbf{r}^{`} \rho_{\mathbf{n}}(\mathbf{r}^{`})\,\mathbf{d}\ \mathbf{r}^{`}\right] \qquad (3)$$

Also

$$\emptyset_{\mathbf{e}}(\mathbf{r}) = -\mathbf{e}\left[\frac{1}{\mathbf{r}}\int_0^{\mathbf{r}} 4\pi \mathbf{r}^{`2}\, \rho_{\mathbf{e}}\,(\mathbf{r}^{`})\mathbf{d}\mathbf{r}^{`} + \int_{\mathbf{r}}^{\infty} 4\pi \mathbf{r}^{`} \rho_{\mathbf{e}}(\mathbf{r}^{`})\,\mathbf{d}\mathbf{r}^{`}\right] \qquad (4)$$

Where r is the distance from centre of nucleus, ρ_n(r `) and $\rho_e$ (r`) denote the space densities (particles per unit volume) of protons in the nucleus orbital electrons, respectively. The exchange potential is defined as[16]

$$\boldsymbol{V_{ex}} = \frac{\mathbf{1}}{\mathbf{2}}[\boldsymbol{E} - \boldsymbol{V_{est}}\ \ (\boldsymbol{r}')] - \frac{\mathbf{1}}{\mathbf{2}}\,[([\boldsymbol{E} - \boldsymbol{V_{est}}(\boldsymbol{r}')]\,)^{\mathbf{2}} + \mathbf{4}\boldsymbol{\pi a_0}\,\boldsymbol{e^4}\,\boldsymbol{\rho}(\boldsymbol{r})] \qquad (5)$$

Where E is the total energy of the projectile depends on the density of electronic charge ρ(r). The correlation-polarization potential V $(r)_{copl}$ consists of two parts; the short-range $V(r)_{SR}$ and the long-range $V(r)_{LR}$ [16-19] and is supplied by:

$$V_{cpol}(r) = \begin{cases} V_{cor}^{SR} & ,r < r_c \\ \\ V_{pol}^{LR} & ,r < r_c \end{cases} \quad (6)$$

Where rc is the intersection point between V_{COT}^{SR} and V_{POl}^{LR} . In the present calculation, two complex scattering amplitudes f (k,θ) (the direct amplitude) and g(k,θ) (the spin-flip amplitude) are defined by [20]:

$$f(k,\theta) = \frac{1}{2ik}\sum_{i=1}^{\infty}\{(l+1)[exp(2i\delta_l^+) - 1] + l[exp(2i\delta_l^-) - 1]\}\ P_1 cos\theta \quad (7)$$

And

$$g(k,\theta) = \frac{1}{2ki}\sum_{i=1}^{\infty}[exp(2i\delta_i^-)\ exp(2i\delta_i^+)]\ \ P_1'\ cos\theta \quad (8)$$

Where θ is the scattering angle and P1'(cosθ) and p1 (cosθ) are the Legendre polynomial and the Legendre associated function, respectively. The elastic differential cross section for scattering of the incident electron beam is given by[21]

$$\rho_u = \frac{d\rho}{du} = |f|^2 + |g|^2 \quad (9)$$

While the spin polarization parameter S(θ) is given by [22]

$$S(\theta) = \frac{i\,(f\,g^* - f^* g)}{\rho_u(\theta)} \quad (10)$$

The spin polarization "Sherman function" S (Θ) describes the spin polarization parameter of the scattered electrons if the incident electron beam is . Also, we can calculate the parameters[16]

$$T(\theta) = \frac{|f|^2 + |g|^2}{\rho(\theta)} \quad (11)$$

And

$$U(\theta) = \frac{f\,g^* - f^*\,g}{\rho(\theta)} \quad (12)$$

3. Results and Discussion

The angular distribution of the elastically scattered electrons of a silver atom at energies of 10, 20, 30, 40, 50, 60, 80 and 100 eV as a function of the angle of scattering 10-150 . It was found that at scattering angles less than 10, the measurements did not appear due to the potential influence of the initial electron beam. However, optical voltage model calculations were performed using SEPSO and SEPASO estimations with the same energies. In this paper, we present the elastic differential cross-sections (DCS) of the scattering of electrons colliding with a silver atom, compared to the experimental measurements of the atom available at different energies. In Fig. 1(i)-(l) DCS is shown for electron collision with silver atom at energies of 10, 20, 30 and 40 eV, respectively. Moreover, Figure 2(m)–(p) displays DCS at energies of 50, 60, 80 and 100 eV, respectively. Note that in the basic approximation to constant current, the zero-angle DCS is indeterminate; therefore, zero corner points in these figures should not be taken lightly. Together with their theoretical calculations under the optical potential method using real and complex partial phase transitions are available at all the above energies . These two different computations are based on complex parameter-free optical capabilities with spin-orbit interaction included. DCS is also compared to Kaur [23], Keegan [24]and Kelemen [6]accounts. Both accounts are available. the shape. [In Figure 1(i)] our results are in better agreement with the experimental measurements by Kaur [23] Kelmen et al.[6] In the whole corner the area ranges except between 80 degrees and 110 degrees. There are other calculations that underestimate the measurements at median angles, i.e. between 60° and 120°. The dip appears at approximately a similar position around 90° as in the SEPSO calculations of Kelemen et al.[6] Similarly, 20 electron volts [Fig. 1(j)], our results reproduce the experimental measurements well [6] up to 110° compared to other calculations, Agreement with the measurements [6] may be due to the choice of exchange and polarization potential. Then, the calculated DCS shows a shallow dip and a back slope of the peak. Measurements are only available up to a scattering angle of 150°. We note a similarity between our results and other calculations for the angle ≥ 50°. for the energy 30eV, Practical outcomes are not available at this energy for comparison. For the only purpose of comparison with the theoretical readings[23], it is evident that the curve's form resembles that of 20 volts but has more pronounced dips. The figure at a power of 40 shows a pattern similar to the theoretical readings [23,6,24] to the pattern shown in the actual observations up to 100°, with a decrease at a similar point of 80° but of a lower magnitude. Then the experimental observations and the present results, which include other calculations, differ in shape and size.

[the Fig. 2 (m) - (p)] at 50, 60, 80 and 100 volts, more pronounced. The surface gradient appears with a higher scattering angle compared to the previous gradient and becomes more pronounced with increasing energy. Figure 2(m) shows DCS at incident power of 50 V where current DCS produces drop at about 80° and 145°. Practical results are not available for comparison at this particular power. Moving on to the next higher energies, and the electron energy at 60 and 80 eV [Fig. 2 (n)-(o)], the present results reproduce the experimental measurements of Kelemen up to 130°. After that, a sharp drop occurs at about 140 degrees. The position of the drop corresponds well with the accounts of Kaur [23] and Keegan [24].etc. however, its reduced size brings it closer to the empirical measurement of kelemen. [6]. Finally, in Fig. 2(p) DCS is shown with a power of 100 V. The present results are compared with the theoretical calculations of Kaur et al. , Keegan [24], and Kelemen et al. [6], Together with the measurements of Kelemen et al. [6]. At this power, our DCS results show fair agreement with the experimental measurements of kelemen. [6] in both shape and size except for about three angles of 60°, 110° and 130° compared to other theoretical results. We also note a similarity between our results and the SEPASo results of kelemen al. [6] Except in the middle corners.

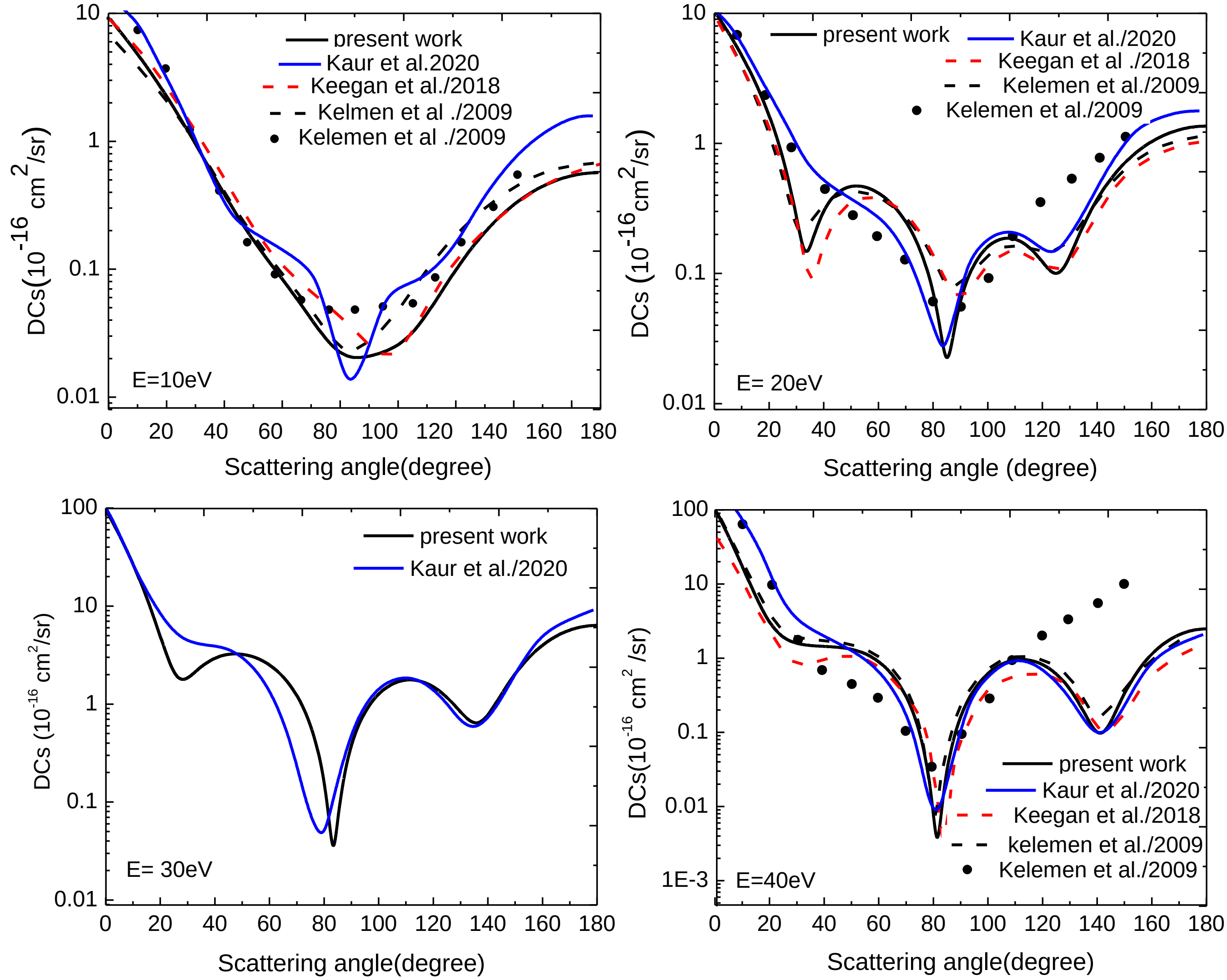

Figure 1: Differential cross sections for scattering from Silver atoms at electron energies of
. 10 eV,20 eV , 30 eV , and 40 eV

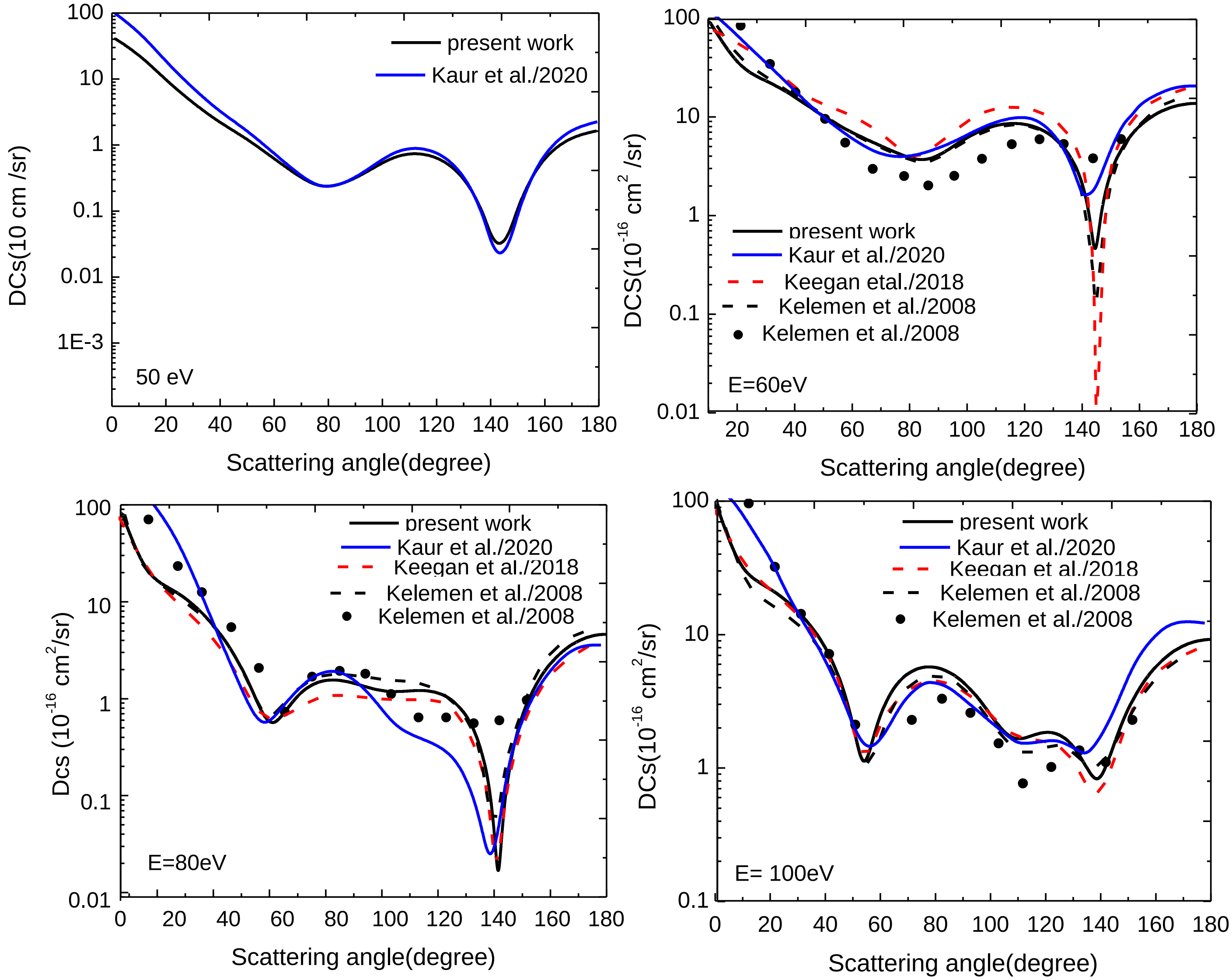

Figure 2: Differential cross sections for scattering from Silver atoms at electron energies of 50 eV,60 eV , 80 eV , and 100 eV

4. Conclusions

The elastic scattering of electrons from silver atom is studied by numerically solving of Dirac equation of the potential model that representing the ejected target interaction consisting of stationary exchange and polarization terms. These terms are important for silver atoms as well as other atomic systems especially for atoms that has high atomic number. Relativistic correction terms according to the spin-orbit interaction become more sensitive at low forcing energies where the dependence of electron exchange, correlation potential and polarization on radial distance, according to relativistic effects in the Dirac equation becomes more important. The scattering functions that obtained in show good agreement with the results of other published works but there are some slight differences between our results for differential cross-sections and total cross-sections with other results due to the absorption component of the optical composite. Furthermore, in the fixed nuclei approximation, the DCS are divergent in the forward scattering and the experimental DCS of Kelemen et al.[6] are available at all of these energies along with their theoretical calculations. At energies of 10,20,,30,40,50,60 and100 eV, the DCS results are in good agreement with the theoretical of Kaur etal.[23],Keleman et al.[6] and keegan et al.[24]and experimental measurements of of Kelemen et al.[6] in the entire angular region except at middle angles between 80◦ and 105◦.At the middle angles, a dip appears similar to the calculations of Kelemen et al.[6], but less magnitude and is in better agreement with measurements.

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المقطع العرضي التفاضلي للاستطارة المرنة للإلكترونات بواسطة ذرة الفضة

احلام خضير ياسر

قسم الفيزياء / كلية العلوم / جامعة البصرة / البصرة / العراق

المستخلص

تم حساب المقطع العرضي التفاضلي (**DCS**) وقياسه نظريًا باستخدام طاقات عرض ثابتة تتراوح من 10 الكترون فولت إلى 100 إلكترون فولت كدالة لزاوية التشتت البالغة 10 إلى 150 درجة. تُستخدم معادلة ديراك النسبية لتقدير المقاطع العرضية لتشتت الإلكترون واستقطاب الدوران للإلكترونات المشتتة من ذرة الفضة. يتم تحليل النتائج المتحصل عليها ومقارنتها بالنتائج النظرية والتجريبية لأبحاث أخرى. تقتصر فائدة هذه الدراسة على الحصول على معلومات حول التشتت.