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Spin polarization and differential cross-sections for $e^{\pm}-$ scattering from rhenium atom

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Abstract. Various scattering cross section such as differential, integrated elastic, momentum transfer, total cross-sections and spin polarization parameters for both the elastic and total scattering of electron and positron from Re atoms in the impact energy range between 2.0 to 500 eV using the relativistic Dirac equations are studies. The target-projectile interaction is included by real and complex- free optical potentials for obtaining the solutions of Dirac equation for scattered electrons and positron. The Dirac-Fock wave functions have been used to represent the $e^{\pm}-$Re target atoms. Corresponding theoretical results are obtained from a relativistic approach based on solving the Dirac equation using Hartree-Fock and Dirac-Fock wave functions to calculate cross sections at all the energies measured.

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Key words: relativistic calculation, electron- positron scattering

1 Introduction

Recently experimental and theoretical work has been focused on heavier atomic target for e.g. Cs, Fr, Pb, Ag, Cu, etc. Theoretical work has been done using relativistic calculations for including spin-effect and its relativistic calculation play an important role in the spin-dependent phenomenon due to collision between incident particles and atoms [1-2]. Anderson and Bartschat [3] have made extensive studies on scattering of electrons from heavy atoms. Due to the development of efficient polarized electrons sources and accurate polarimeters, spin dependence of scattering processes can be easily studied through the complete scattering experiment. Within the framework of density matrix formalism

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one can define a set of observables parameters viz. the unpolarized differential cross-section (DCS) and polarization parameters S, T and U. The polarization parameter S is known as Sherman function, which describes the change of polarization produced in the scattered beam due to collision, and the other two T and U parameter give the angle of rotation of the components of the polarization vector in the scattering plane.

Theoretically, Walker and Lam [4–6] studied electron and positron scattering using the relativistic form of the Schrödinger equation, Haberland *et al.* and Bartschat *et al.* have studied scattering processes using the generalized Kohan-Sham type equations, static exchange R-matrix theory and real and complex model potential approach respectively [7–12]. Most of the calculation performed for the positron-atom scattering which are based on model potential approach by using the similar form of polarization and absorption potentials [13–16]. However, the positron offers an altogether different collision process, the possibility of genuine rearrangement -positronium (Ps) formation. If the ionization energy of the atom is greater than 6.8 eV, the positronium channel opens at binding energy. The incident positron sees an attractive field due to the characteristics effect of the Ps-formation on the elastic channel. The close-coupling calculations, which include the Ps-channel explicitly, have been used routinely for positron-hydrogen and alkali systems rather than heavier target [17–23]. Dorn *et al.* [23] carried out calculations for spin polarization of xenon atoms using an optical potential including both polarization and absorption effects. Their results show that absorption potential must be included in the relativistic description for accurate prediction of the S, T, and U parameters. This aspect of electron and positron scattering from heavy atoms has been further examined by Neerja *et al.* [24–26]. Recently, Nikolić and Tančić and Harish Mohan *et al.* [27–28] studied the low energy elastic scattering of positrons by inert target.

This paper involves the detailed study of atomic behavior of Re ([Xe] 6s (2)4f (14)5d (5)) atom using electron and positron scattering. We have used parameter-free model optical potential approach [25, 34] for calculating the DCS, S-parameter, momentum and total cross-sections of electron and positron scattering from Re atom.

2 Theoretical methodology

2.1 Choice of potentials

The total interaction between a particle and the target atom is represented by an effective potential $V(r)$, which is sum of two parts, $V_R(r)$ and $V_A(r)$. For electron scattering, real part of the potential $V_R(r)$ is expressed as sum of three local terms, $V_R(r) = V_{st}(r)+V_{ex}+V_{pol}(r)$, where $V_{st}(r)$, V_{ex} and $V_{pol}(r)$ are static, exchange and polarization potentials respectively. However for positron scattering, $V_R(r) = V_{st}(r)+V_{pol}(r)$. All potential terms are functions of ground state density $\rho(r)$ of the target. The static potential $V_{st}(r)$ and the charge density $\rho(r)$ are obtained using non-relativistic Slater type orbital's of Roothan and Hartree-Fock wave functions as given in McLean [29]. In addition, we have used the compilation of analytical function given by Salvat *et al.* [30], which is