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Excitation Cross Section of Argon by Positon Impact at 14.0eV

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Abstract

We have computed excitation cross section (ECS) of Argon by positron impact using time dependent close coupling method at low energy range i.e. 14.0eV. High quality Hartree - Fock Slater orbitals are used to model the target wave function. We have computed the excitation results for noble gases (Ne, Ar, Kr and Xe), but here we are presenting only for Argon atom. Full orthogonalization significantly improves agreement with experimental data for the noble gas series. We have compared ECS results with other available theoretical data as well as experimental measurements. Our present results are found in excellent agreement with other calculations. However some discrepancies suggested that more and more theoretical as well as experimental work is required in future.

Keywords: Positron, Excitation, Close Coupling

Introduction

The accurate determination and understanding of positron impact induced atomic collision processes is important for a number of reasons. From a practical perspective, the modelling of many systems of environmental and technological interest relies on the incorporation of cross section data to describe collision processes at microscopic scale. These cross sections predict reaction rates for the range of possible collision outcomes comprising elastic scattering, excitation and ionization. Thus the provision of precise cross section data is vital to these applications.

In the area of positron atom collision, the positron – noble gas system has been a prime focus of study over many years. The present study concerns the excitation of Argon atoms close to threshold. Argon represents the most ubiquitous noble gas of the earth's atmosphere comprising around 0.93% of its composition. It is used in a variety of applications including medical lasers, plasma processing, in condescend lighting and welding etc. Positron impact excitation data for Argon is needed for many applications. In fusion, Argon is under consideration as a potential means of mitigating plasma disruptions in ITER by the injection of either cryogenic pellets or high pressure gas jets. In astrophysics, X-ray satellites require accurate excitation data for Argon to serve as plasma diagnostics of stellar electron temperature and density.

Zatsarinny and Bartchat [1] presented Breit-Pauli B-spline R matrix [BSR] calculations in closed coupling expansion. Ballance and Griffin [2] extended the R-matrix method with orthogonal orbitals by including a large number of pseudostates for the excitation of Argon by electron impact. Du Bois *et al* [3] have been observed triple differential cross sections data for Argon by positron impact. An optical potential method for elastic electron and positron scattering from Argon was used by McEachran and Stauffer [4]. Very recently Ludlow *et al* [5] provided electron impact excitation of Argon. They spoke that electron impact excitation of Argon is a vital component in the modelling fusion Tokamak experiments. These data would subsequently be achieved as Maxwellian averaged rate coefficients. Gangwar *et al* [6] have used distorted wave approximation to calculate excitation of Argon from ground state and presented the results in the energy range up to 100eV.

Here we focus on positron impact excitation of Argon from $3p^6$ ground state to $3p^54s$ (lowest excited state) using Breit-Pauli relativistic model (BPRM) at low energy range i.e. 14.0eV.

Theory

A detailed description of theoretical calculation can be found in our previous publication. In the case of positron impact excitation of target inert atom is given by

$$\frac{d\sigma}{d\Omega} = \frac{4k'K^2}{kq^4}\left|\left(e^{-iq.r}\right)_{nlm\,K}\right|^2 d\Omega_K dK \qquad ----(1)$$

where $d\Omega_K$ is the element of solid angle. n, l and m are the usual principal, orbital and magnetic quantum numbers respectively. k is the incident positron momentum directed along positive z direction, k′ is the scattered positron momentum and K is ejected electron momentum. The matrix element is given by

$$\left(e^{-iq.r}\right)_{nlm\,k} = \int \psi_K^{(-)*} e^{-iq.r}\,\phi_{nlm}\,d^3r \qquad ----(2$$

where ϕ_{nlm} is the target orbital wave function and $\psi_K^{(-)*}$ is the ejected electron wave function

To evaluate equation (1), all momenta in the equation must be expressed in terms of the known variables and the integration variables. These are given by

$$k = \sqrt{2E} \qquad ----(3)$$

$$k' = \sqrt{2\left(E - E_0 - \frac{K^2}{2}\right)} \qquad ----(4)$$

$$q = k^2 + k'^2 - 2kk'\cos\theta \qquad ----(5)$$

where E is the incident positron energy, E_0 is the ionization energy of the target orbital and θ is the angle between k′ and positive z axis.

Results and Discussion

Figure shows the present ECS calculation at 14.0eV with experimental data [7] and the theoretical calculation (BSR) using B-spline R-matrix method [1]. At this energy excellent agreement is observed between present (BPRM) results and the experimental data. However surprisingly the BSR calculation described very well the Shape of experimental and present ECS, but their cross sections are quite lower than those. The possible cause for this disparity could be related to a potentially high sensitivity of the derived cross sections.

The present study focuses on the near threshold region where the disparities between theoretical and experimental results have revealed. The aim of this work is to seek closing the gap between

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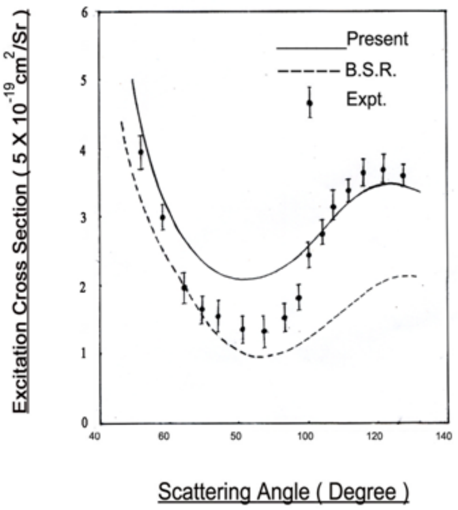
experiment and theory. Therefore more experimental results are required for this excitation process.

Fig. 1: Excitation cross section of argon by positon impact at 14.0eV



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