High energy elastic $e^+ - O_2$ scattering

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Abstract. Theoretical differential cross-sections are obtained for the elastic scattering of fast ($E_i \geq 200$ eV) positrons by oxygen molecules. Employing the independent atom model, the atomic scattering amplitudes are calculated with the (static + polarization) model potentials, in the partial wave analysis (PWA). Comparisons made with the theory and experiments on the incident electrons, show significant differences at small angles.

Keywords. Positron scattering; static potential; polarization potentials; partial waves.

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1. Introduction

This paper is an addendum to the previous paper on $e^- - O_2$ scattering (Joshipura 1989, to be referred to as paper I). There have been recent experiments on inelastic collisions of positrons with oxygen molecules (e.g. Katayama et al. 1987), but there are hardly any data on elastic $e^+ - O_2$ scattering, especially at intermediate and high energies. With positrons of intermediate and high energies, whereas the positronium formation may be ignored, considerable differences compared to electron scattering are still expected. The nature and extent of these differences, depend on the projectile energy for a particular target, hence the present investigation. The calculations of paper I are refined presently in two ways viz., by choosing an improved atomic static potential and by employing a better partial wave treatment of the long range polarization potential. Comparisons of our positron results are made with theory and experiments on incident electrons.

2. Theoretical calculations

Concentrating on the problem of positron scattering by atomic oxygen, we write the total interaction as a sum of static and polarization potentials, i.e.

$$V(r, k_i) = V_{st}(r) + V_{pol}(r, k_i).$$  \hspace{1cm} (1)

The first term of (1) is obtained following Salvat et al. (1987), who have calculated and parametrized the Dirac-Hartree-Fock-Slater screening functions for neutral atoms from $Z = 1$ to 92. Thus, we have,

$$V_{st}(r) = \frac{8}{r} [0.0625 \exp(-14.823r) + 0.9375 \exp(-2.0403r)].$$ \hspace{1cm} (2)
The polarization potential is the same as in paper I. We may add here that, if the incident particles are electrons, a term $V_{ex}$ corresponding to the exchange effect must be added in (1). Now, with the optical potential described heretofore, the Schrödinger scattering equation is solved numerically to obtain phase-shifts $\delta_l$ in the partial wave analysis (PWA). For the long range polarization potential the first few phase-shifts ($l \sim 10$) are determined through the Numerov method for the scattering solution and the higher partial wave phase-shifts are obtained analytically, following the Born approximations calculated by Wadehra (1986). After having obtained the partial wave scattering amplitudes for positrons incident on oxygen atoms, the independent atom model (see paper I) is employed to calculate the DCS of $e^+ - O_2$ scattering.

3. Results and discussion

Though our aim is to obtain the DCS of positrons on $O_2$ molecules, we have also calculated the same for incident electrons, to afford comparison. We have exhibited in figures 1 and 2 the $e^+$ and $e^-$ DCS at 200 and 500 eV respectively. In figure 2, the curves represent theoretical results on positrons alone.

The PWA calculations for electrons, including exchange (Riley and Truhler 1975), show a fair agreement with the measured data of Daimon et al (1982) as well as Iga et al (1987). At 200 eV the results of Iga et al (1987) are not available. Because of the success with electrons, we expect our theoretical results on positrons to be reliable.

The most remarkable feature of our results is the behaviour of the positron

![Figure 1. DCS of $e^+$ and $e^-$ scattering from $O_2$ at 200 eV.](image-url)