TOTAL CROSS SECTIONS FOR POSITRONS SCATTERED ELASTICALLY FROM HELIUM BASED ON NEW MEASUREMENTS OF TOTAL IONIZATION CROSS SECTIONS*

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ABSTRACT

We have applied an improved technique for employing our 2.3m spectrometer to measure total ionization cross sections, Q_{ion}, for positrons incident on He. The new Q_{ion} agree with the values we reported earlier. We present, also, estimates of total elastic scattering cross sections, Q_{el}, obtained by subtracting from total scattering cross sections, Q_{tot}, reported in the literature, our Q_{ion} and Q_{Ps} (total positronium formation cross sections) and total excitation cross sections, Q_{ex}, published by another researcher. The Q_{ion} and Q_{el} measured with our 3m high-resolution time-of-flight spectrometer for 54.9eV positrons are in accord with the results from the 2.3m spectrometer. The Q_{ion} are in fair agreement with theory tending for the most part to be higher, especially at 76.3 and 88.5eV. Our Q_{el} agree quite well with theory to the vicinity of 50eV, but at 60eV and above the experimental Q_{el} climb to and remain at about $0.30\pi a_0^2$ while the theoretical values steadily decrease.

INTRODUCTION

Our 2.3m spectrometer was put into its present form[1] to permit absolute, direct measurements of Q_{ion} and to simplify absolute determinations of Q_{Ps} for positrons incident on gases. We have applied an improved technique to extend the range of our first Q_{ion} measurements[2] in He. We compare these new preliminary results with theory and subtract them, our values for Q_{Ps} (Ref. 1), and Sueoka's results for Q_{ex} from Q_{tot} obtained from published values[4,5] to arrive at estimates of Q_{el}. A recent elaborate study of positron-helium partial cross sections has been published by Campeanu _et al_. (Ref. 12).

METHOD

We compute Q_{ion} from $Q_{ion}=fQ_{tot}/F$, where f is the fraction of incident positrons that produce ions by impact, F is the fraction that scatter into all channels, and Q_{tot} is obtained from the literature.

Reporting Q_{ion} in this way permits scaling the results to any set of Q_{tot}. We use those of Ref. 4 and 5 here because they are more recent than of our own. The apparatus used, the measurement of F, the calculation of the correction for double scattering, and possible sources of systematic error are fully discussed in Ref. 1. Counting the ionization electrons and the beam positrons equal periods of time allows the calculation of f. The current technique for couning ioniza-

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tion electrons is to apply to the cone of the channel electron multiplier a voltage that is sufficiently low to prevent reflection of the beam positrons and consequent multiple passes through the target gas. This change of procedure enabled us to extend Q_{ion} determinations with this spectrometer to lower beam energies than were formerly tractable at a minor cost of applying a small correction for counting beam positrons together with the ionization electrons.

RESULTS AND DISCUSSION

The results are shown in Fig. 1. The open square shows a Q_{ion} obtained with our 3m high-resolution time-of-flight (TOF) spectrometer,[6] the solid line is drawn through the calculated points (+) of Mukherjee et al.[7] The Q_{ion} (o) are in fair agreement with theory, tending for the most part to be higher especially at 76.3 and 88.5 eV. The open stars depict Q_{el} that resulted from subtracting Q_{ion}, Q_{Ps} (Ref. 1 or 8) and Q_{ex} (Ref. 3) from Q_{tot} (Ref. 4 or 5). The x was determined by smoothly extrapolating Q_{tot} (Ref.4) from energies just below the positronium formation threshold energy to that energy. The two Q_{el} represented by triangles are for energies below the threshold for impact ionization and were calculated by subtracting Q_{Ps}[8] and Q_{ex}[9] from Q_{tot} (Ref. 4). The diamond resulted from employing in the subtractions the TOF Q_{ion}. The open cross shows a Q_{el} directly measured with the TOF spectrometer (Ref. 6) Its value will increase upon application of corrections.

The curve of mid-length dashes guides the eye through the experimental Q_{el} as their values dip just above the positronium formation threshold and climb to $0.30\pi a_0^2$ at 60eV. The curve of long dashes joins Q_{el} calculated by McEachran and Stauffer,[10] which agree well with the experimental values up to the vicinity of 50eV, after which they decline steadily.

The solid stars represent Q_{el} obtained by subtracting from Q_{tot} (Ref. 4 or 5), Q_{ex} (Ref. 3) and the Q_{Ps} and Q_{ion} from Ref. 11.

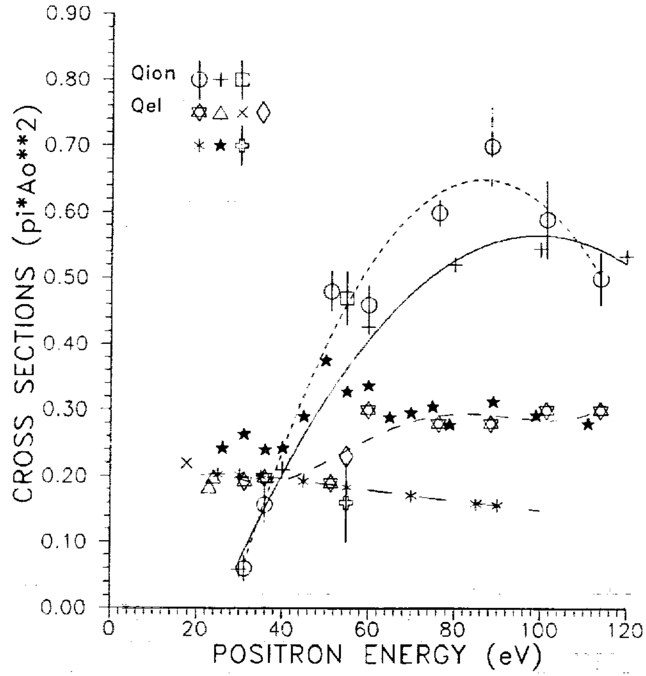

Fig 1. Total elastic and total impact ionization cross sections in He. See text for explanations of symbols.

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