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

L. M. Diana, R. L. Chaplin, D. L. Brooks
J. T. Adams, L. K. Reyna

The University of Texas at Arlington
Center for Positron studies
Department of Physics
Arlington, TX, U.S.A.

ABSTRACT

We have applied an improved technique for employing our 2.3m spectrometer to measure total ionization cross sections, $Q_{\text{ion}}$, for positrons incident on He. The new $Q_{\text{ion}}$ agree with the values we reported earlier. We present, also, estimates of total elastic scattering cross sections, $Q_{\text{el}}$, obtained by subtracting from total scattering cross sections, $Q_{\text{tot}}$, reported in the literature, our $Q_{\text{ion}}$ and $Q_{\text{Ps}}$ (total positronium formation cross sections) and total excitation cross sections, $Q_{\text{ex}}$, published by another researcher. The $Q_{\text{ion}}$ and $Q_{\text{el}}$ 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 $Q_{\text{ion}}$ are in fair agreement with theory tending for the most part to be higher, especially at 76.3 and 88.5eV. Our $Q_{\text{el}}$ agree quite well with theory to the vicinity of 50eV, but at 60eV and above the experimental $Q_{\text{el}}$ 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 form1 to permit absolute, direct measurements of $Q_{\text{ion}}$ and to simplify absolute determinations of $Q_{\text{Ps}}$ for positrons incident on gases. We have applied an improved technique to extend the range of our first $Q_{\text{ion}}$ measurements2 in He. We compare these new preliminary results with theory and subtract them, our values for $Q_{\text{Ps}}$ (Ref. 1), and Sueoka's results for $Q_{\text{ex}}$ from $Q_{\text{tot}}$ obtained from published values4,5 to arrive at estimates of $Q_{\text{el}}$. A recent elaborate study of positron-helium partial cross sections has been published by Campeanu et al. (Ref. 12).

METHOD

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

Reporting $Q_{\text{ion}}$ in this way permits scaling the results to any set of $Q_{\text{tot}}$. 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 $f$.

*We thank Dr. P. G. Coleman for important past and continuing contributions.
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 \( Q_{\text{ion}} \) 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 \( Q_{\text{ion}} \) 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 \( Q_{\text{ion}} \) (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 \( Q_{\text{el}} \) that resulted from subtracting \( Q_{\text{ion}} \), \( Q_{\text{Ps}} \) (Ref. 1 or 8) and \( Q_{\text{ex}} \) (Ref. 3) from \( Q_{\text{tot}} \) (Ref. 4 or 5). The x was determined by smoothly extrapolating \( Q_{\text{tot}} \) (Ref. 4) from energies just below the positronium formation threshold energy to that energy. The two \( Q_{\text{el}} \) represented by triangles are for energies below the threshold for impact ionization and were calculated by subtracting \( Q_{\text{Ps}} \) (Ref. 8) and \( Q_{\text{ex}} \) (Ref. 9) from \( Q_{\text{tot}} \) (Ref. 4). The diamond resulted from employing in the subtractions the TOF \( Q_{\text{ion}} \). The open cross shows a \( Q_{\text{el}} \) 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 \( Q_{\text{el}} \) as their values dip just above the positronium formation threshold and climb to 0.30nm at 60eV. The curve of long dashes joins \( Q_{\text{el}} \) 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 \( Q_{\text{el}} \) obtained by subtracting from \( Q_{\text{tot}} \) (Ref. 4 or 5), \( Q_{\text{ex}} \) (Ref. 3) and the \( Q_{\text{Ps}} \) and \( Q_{\text{ion}} \) from Ref. 11.

ACKNOWLEDGMENTS

We wish to acknowledge the generosity of R. P. McEachran and A.D. Stauffer in supplying their calculated \( Q_{\text{el}} \). We appreciate, also, the support of the National Science Foundation through Grant PHY-8506933.

REFERENCES


