N90-18974

POSITRON-INERT GAS DIFFERENTIAL ELASTIC SCATTERING

W.E. Kauppila, Steven J. Smith, C.K. Kwan, and T.S. Stein
Department of Physics and Astronomy, Wayne State University
Detroit, Michigan 48202 USA

ABSTRACT

Measurements are being made in a crossed-beam experiment of the relative elastic differential cross section (DCS) for 5-300 eV positrons scattering from inert gas atoms (He, Ne, Ar, Kr, and Xe) in the angular range from 30-134°. Results obtained at energies around the positronium (Ps) formation threshold provide evidence that Ps formation and possibly other inelastic channels have an effect on the elastic scattering channel.

INTRODUCTION

It is well known that DCS measurements provide a sensitive test of theoretical calculations. Furthermore, positron scattering by the inert gas atoms is particularly interesting because as the positron energy is increased above the lowest inelastic scattering threshold energy (for Ps formation) it is known[1] that the total cross sections increase rapidly and that Ps formation may quickly become as large or even larger than the elastic scattering cross section. As a result, measurements of positron elastic DCSs for the inert gases provide some good examples for investigating the effect of an inelastic scattering channel (e.g., Ps formation) on the elastic channel as the positron energy is increased through the Ps formation threshold.

EXPERIMENT

The basic experimental setup (shown in Fig. 1) and approach is the same as that used by Hyder et al.[2] Some modifications that have been made to improve the acquisition of data are the addition of (1) a second channeltron to detect scattered positrons, (2) a 150 millicurie sodium-22 positron source, and (3) a baffle between the primary beam path and channeltron #2. The origin of the

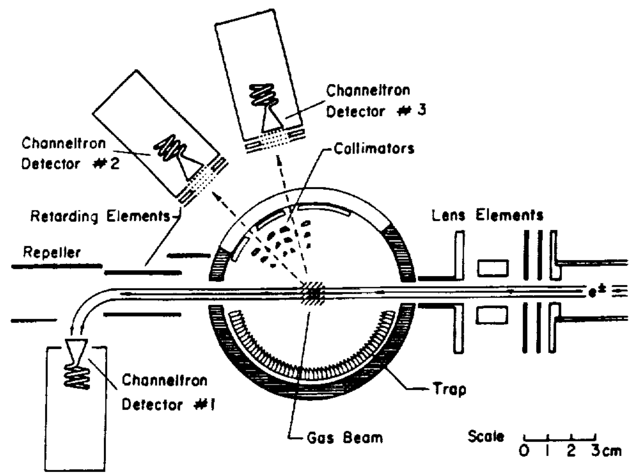

Figure 1

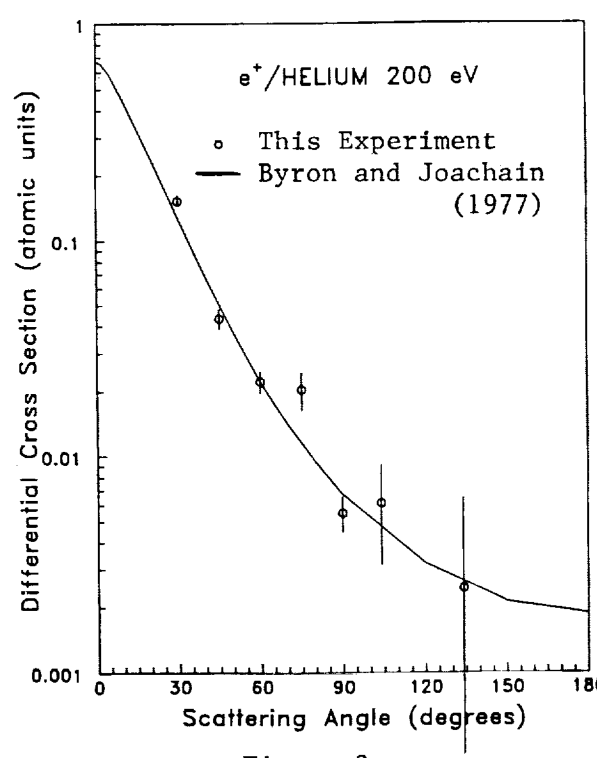

Figure 2

slow positron primary beam (intensity >100,000/sec at 100 eV with a FWHM of about 1.5 eV) is an annealed tungsten moderator placed in front of the sodium-22 source. Geometrical considerations and electron measurements made in the same system (and compared with prior experiments) indicate an overall angular resolution in the vicinity of $\pm 10^{\circ}$. The accuracy of our measurement angles is within a few degrees.

RESULTS

A sampling of our initial elastic DCS measurements (with statistical uncertainties) taken with our modified apparatus for the inert gases is shown in Figs. 2-6 where they are compared with various calculations[3-7] and some earlier measurements of Hyder et al.[1] In each case our results are normalized to a calculation at either 60 or 90°. We do not consider meaningful the few 134° values that seem out-of-line with the smaller angle values.

At high energies it is seen that our results are in good agreement with the eikonal Born series method calculation (within the framework of the optical model formalism) of Byron and Joachain[3] at 200 eV for He and the optical model calculations of Joachain et al.[6] for Ar at 300 eV. It is to be noted that the present measurements are about a factor of two lower at 30° than Hyder et al.[2], which we attribute to the addition of the above-mentioned baffle.

At positron energies just below the Ps formation thresholds we are finding quite good agreement with the polarized orbital calculations of McEachran et al.[4,7,8], as is seen in Fig. 6 at 5 eV for Xe and reported by Smith et al.[9] for Ne at 13.6 eV and Ar at 8.7 eV. For positron impact energies somewhat above the Ps formation thresholds we have been finding that our DCS measurements are appreciably different than the above polarized orbital calculations, as shown in Fig. 5 for Kr at 20 eV and by Smith et al. for Ar at 30 eV. It is to be noted that these polarized orbital calculations

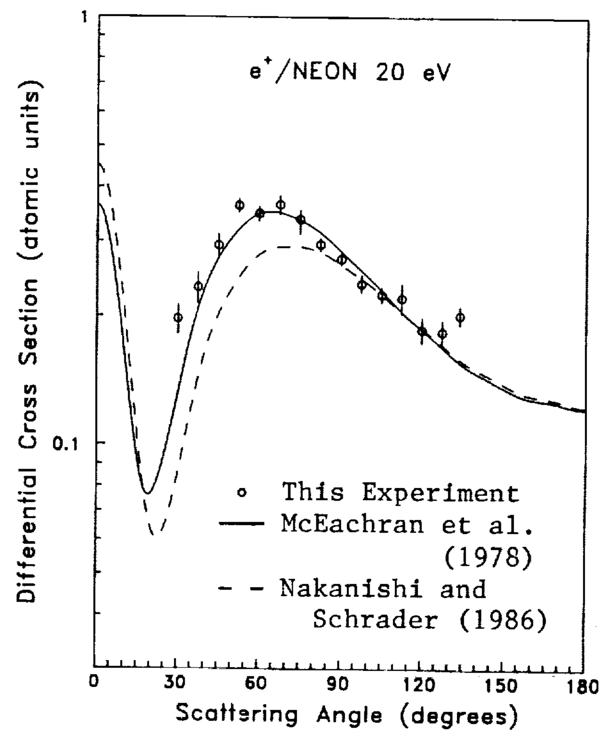

Figure 3

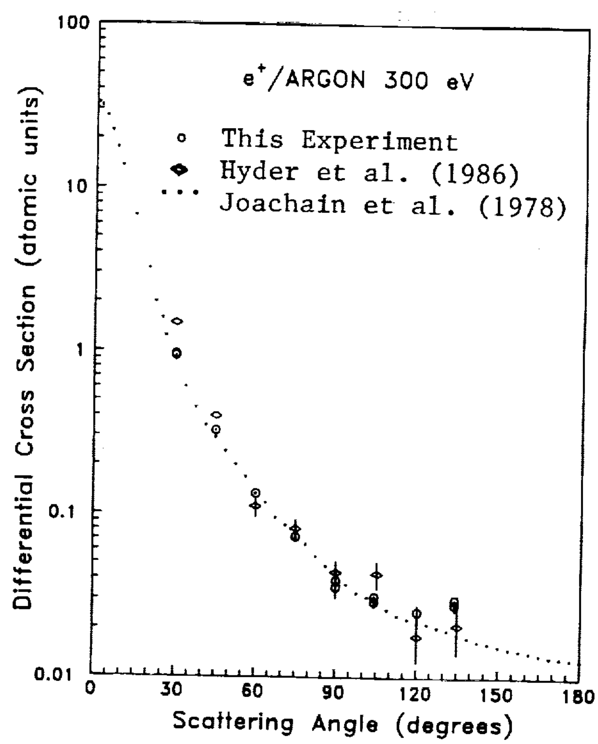

Figure 4

do not include any consideration for the effect of inelastic scattering channels on the elastic channel. Calculations have been made by Bartschat et al.[10] and Joachain and Potvliege[11] where the effect of inelastic channels on the elastic channel (referred to as absorption effects) have been considered and both of these groups have found that these absorption effects tend to remove the structure (minimum and maximum) in the DCS curves, which is somewhat consistent with what we observe for Kr at 20 eV (Fig. 5) and Ar at 30 eV (Smith et al.[9]). Our 20 eV Ne results in Fig. 3 are close to the calculation of McEachran et al.[4]

ACKNOWLEDGEMENTS

We acknowledge the helpful assistance of James Klemic. This work was supported by NSF Grant PHY-8706120.

REFERENCES

1. W.E. Kauppila and T.S. Stein, Adv. At. Mol. Phys. 26, 1 (1989/1990).
2. G.M.A. Hyder, M.S. Dababneh, Y.-F. Hsieh, W.E. Kauppila, C.K. Kwan, M. Mahdavi-Hezaveh, and T.S. Stein, Phys. Rev. Lett. 57, 2252 (1986).
3. F.W. Byron Jr. and C.J. Joachain, Phys. Rev. A 15, 128 (1977).
4. R.P. McEachran, A.G. Ryman, and A.D. Stauffer, J. Phys. B. 11, 551 (1978).
5. H. Nakanishi and D.M. Schrader, Phys. Rev. A 34, 1823 (1986).
6. C.J. Joachain, in Electronic and Atomic Collisions, edited by G. Watel (North-Holland, Amsterdam, 1978), p. 71; C.J. Joachain, R. Vanderpoorten, K.H. Winters, and F.W. Byron Jr., J. Phys. B 10, 227 (1977).
7. R.P. McEachran, A.D. Stauffer, and L.E.M. Campbell, J. Phys. B 13, 1281 (1980).
8. R.P. McEachran, A.G. Ryman, and A.D. Stauffer, J. Phys. B. 12, 1031 (1979).
9. S.J. Smith, W.E. Kauppila, C.K. Kwan, and T.S. Stein, Proc. ICPEAC XVI, Abstracts (1989). (to be published).
10. K. Bartschat, R.P. McEachran, and A.D. Stauffer, J. Phys. B 21, 2789 (1988).
11. C.J. Joachain and R.M. Potvliege, Phys. Rev. A 35, 4873 (1987).

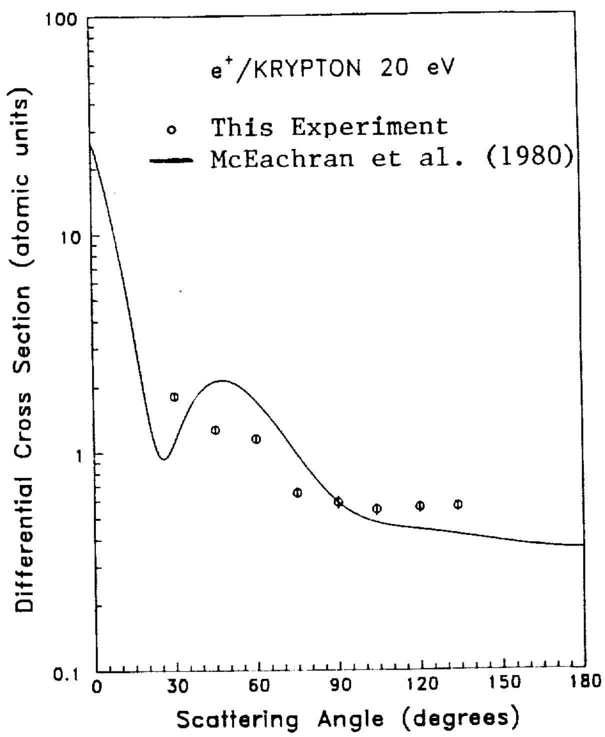

Figure 5

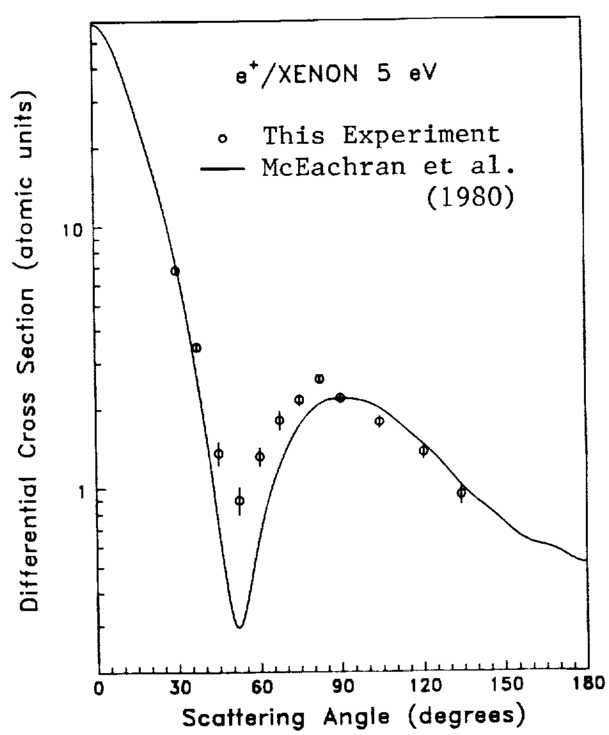

Figure 6