NEW RESULTS IN POSITRON SCATTERING FROM NOBLE GAS ATOMS AND DIATOMIC MOLECULES

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In this talk, I discuss new data on the formation of Ps atoms by positron impact [1]. Ps formation represents a very significant theoretical challenge. From an experimental point of view, while there have been a number of experimental studies of Ps formation in noble gases, there is significant disagreement as to the magnitude and shape of the cross sections. Additionally, positron annihilation, which frequently occurs via this intermediary Ps state, is frequently exploited in applications of positrons to material science and biophysics.

The experiment described here uses a trap-based positron beam [2] with an energy spread ~ 25 meV (FWHM). It is tunable from ~ 50 meV upwards. The measurements are done in a strong magnetic field (i.e. 0.1 T). Regions of variable magnetic field strength are used to distinguish elastic and inelastic scattering events.

Results will be presented for the absolute direct and total ionization and Ps formation cross sections in Ne, Ar, Kr, Xe, at energies from threshold up to 90 eV. The experimental data for Ps formation will be compared with the most recent measurements of these cross sections obtained using a significantly different technique [3]. There is excellent agreement between the total ionization cross sections. However in the direct ionization and positronium formation there are some significant disagreements (e.g. the previous report of a second peak in the Ps formation cross section in Ar), and they will be discussed.

In addition to the direct measurements of Ps formation, another analysis will be described that provides an independent measurement of the Ps formation cross sections. The results of this analysis and the direct measurements presented here are in good agreement for Ar, Kr and Xe [1]. These results will be compared with previous experimental measurements and with previous and new theoretical predictions. New theoretical predictions for the direct ionization cross sections are in reasonably good agreement with the data. The Ps formation predictions are less able to match the experimental cross sections.

Results for the direct and total ionization of the diatomic molecules, N_2, CO and O_2 will also be presented and compared to other available measurements and theoretical predictions. There is generally good agreement between the present and previous experimental measurements for these targets, thus providing an important benchmark for theory.

Updated and new results for the electronic excitation of N_2 and CO by positron impact will be presented. These isoelectronic diatomic molecules were chosen because N_2 has been shown to be such an effective buffer gas for trapping positrons. Comparison of the new results for Ps formation (the major loss process in buffer gas traps) and the electronic excitation cross sections sheds light on these competing interactions inside a buffer gas trap.

It has been experimentally noted that the addition of CF_4 gas in the third stage of the trap leads to a faster cooling rate. This effect has been investigated by measuring the vibrational excitation cross section of CF_4 as a function of incoming positron energy, and will be presented.

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References

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