Positron Scattering from Atoms and Molecules

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Summary

This thesis reports on total cross section results of positron scattering measurements for fourteen atomic and molecular targets in the energy range between ~0.1-50 eV. The investigated targets include the noble gases argon and krypton, the diatomic species molecular hydrogen, the isoelectronic molecules carbon monoxide, molecular nitrogen and acetylene, the primary alcohols methanol and ethanol, and some molecules of biological interest: specifically formic acid, tetrahydrofuran, 3-hydroxy-tetrahydrofuran, tetrahydrofurfuryl alcohol, dihydropyran and pyrimidine. In addition, positronium formation and elastic differential cross sections for tetrahydrofuran are also presented. The experiments were undertaken with the positron spectrometer at the University of Trento in Italy, and with the atomic and molecular buffer-gas trap and positron beam apparatus at the Australian National University in Canberra.

The present total cross section measurements on ethanol and all the biomolecules, except for tetrahydrofuran, appear to be original. The current results for the other pre-studied targets, instead, extend the range of the existing measurements to much lower energies and therefore provide the very first results to validate the available theoretical models in this energy range.

Discussion of the present results is provided in terms of the role played by the relevant physico-chemical properties of the target on the low energy scattering dynamics. The more or less significant dipole polarisability and permanent dipole moment of the investigated species, are found to be responsible for the large magnitude and the dramatic energy dependence of the measured cross sections at very low energy. These properties can considerably affect the attractive dipole interaction between the incoming positron and the target, so that it overcomes the repulsive static potential, leading to a nett attractive interaction. This is, in turn, reflected by the increased probability of scattering at those low energies, as compared to the higher energies.

Comparison with earlier experimental data and existing calculations, where available, is also presented. Fairly good agreement with previous measurements is typically found only above the positronium formation threshold energy. Below that threshold, the present cross sections are usually higher in magnitude, possibly owing to the superior angular discrimination of the spectrometer employed in the current measurements. Poor or marginal agreement is often found with the available calculations, except for the atomic targets where the accord turns out to be good when we

compare with the most recent results. This indicates that some further quite significant development in positron scattering models is needed.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

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Luca Chiari

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