Experimental investigations of positron-molecule scattering resonances

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Positrons are the most easily accessible form of antimatter for use in experiments, and have been the basis of both fundamental and practical interest for many years. For instance, Positron Emission Tomography (PET scan) is now a widely used imaging tool in hospitals around the world. From a more basic point of view, it is interesting to study the interactions of positrons with atoms and molecules, to test our understanding of these quantum interactions. This has been the focus of many research programs since the discovery of positrons in the early 1930s [1]. With the development of the Surko trap and beam system [2], a new tool was available with unprecedented energy resolution and control, opening up new avenues of investigation of low energy scattering processes. At the Australian National University, we have a beam with energy resolution of better than 50 meV [3], which is used to study a wide range of processes.

One interesting problem is the question of whether a positron can form a bound state with an atom or molecule. There have been many predictions of such systems, but the first experimental evidence came with the measurement of the low energy annihilation cross section of hydrocarbons [4]. This discovered a series of vibrational Feschbach resonances, which are a byproduct of a supported bound state between a positron and the molecule in question. Further theoretical study of these complexes predicts a coupling between the resonant state and the vibrational modes of the molecule, which should be able to be observed in the vibrational excitation cross sections [5]. The study presented here measures these cross sections, to elucidate the decay processes of the positron-molecule scattering resonances and compare to theoretical prediction. Positron induced vibrational excitation cross sections have been measured from a range of simple hydrocarbons - ethane, ethylene and acetylene. This talk will present this data and explore the significance of the results in terms of our understanding of positron scattering resonances.

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