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Bound States and Feshbach Resonances in Positron-Molecule Annihilation[1]

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Considerable progress has been made recently in studying positron-molecule interactions using trap-based beams. Measurements of energy-resolved positron- on-molecule annihilation in alkane molecules have solved a four-decade mystery regarding the origin of very large positron-molecule annihilation rates [1-3]. Studies indicate that positrons can become temporarily bound to a variety of molecules via vibrational Feshbach resonances (VFR). These VFR manifest themselves as peaks of varying intensity in the annihilation spectra, with energies shifted below those of the vibrational modes by a molecule-dependant binding energy ϵ_b. It is now possible to make quantitative predictions for the annihilation spectra in small, infrared-active molecules [2]. Furthermore, using this formalism, it is possible to discern broad empirical trends in the spectra of larger molecules. In particular, after normalizing out a weak dependence on ϵ_b, resonant annihilation rates in nearly all hydrocarbons studied to date obey a 'universal' scaling with the number of vibrational degrees of freedom [3]. The origin and significance of this scaling will be discussed. The only known outliers to this scaling, partially fluorinated alkanes, are shown to exhibit an additional inelastic channel, which diminishes the magnitudes of resonances above an energy threshold. Outstanding questions will be discussed, including understanding the chemical trends in positron-molecule binding energies and the role of intramolecular vibrational energy redistribution (IVR) in determining the magnitudes of the annihilation VFR peaks.

[1] L. D. Barnes, J. A. Young, and C. M. Surko, *Phys. Rev. A* **74**, 012706 (2006).
[2] G. F. Gribakin and C. M. R. Lee, *Phys. Rev. Lett.* **97**, 193201 (2006).
[3] J. A. Young and C. M. Surko, *Phys. Rev. Lett.* **99**, 133201 (2007).

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