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Resonances and Bound States in Positron Annihilation on Molecules[1]

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Positron annihilation is important in such diverse areas as study of metabolic processes in the human brain and the characterization of materials. Annihilation on molecules has been a subject of keen interest for decades. In particular, annihilation rates can be orders of magnitude greater than those expected for simple collisions. Recent results put our understanding of many aspects of this long-standing problem on a firm footing. We now understand that the annihilation proceeds by vibrational Feshbach resonances (VFR). A prerequisite for the existence of these VFR is that the positron binds to the target. The annihilation energy spectra provide the best measures to date of positron binding energies. Predictions of a new theory of VFR-enhanced annihilation in small molecules (methyl halides) [1] show excellent, quantitative agreement with experiment. New data and analyses for larger molecules (e.g., hydrocarbons with more than two carbon atoms) show that annihilation rates depend strongly on the number of vibrational degrees of freedom but, surprisingly, only weakly on positron binding energy. This places important constraints on theories of annihilation in these molecules. Results for second bound (i.e., positronically excited) states and overtone and combination-mode VFR, as well as outstanding questions, will also be discussed. This work is done in collaboration with Jason Young.

[1] G. F. Gribakin and C. M. R. Lee, Phys. Rev. Lett. 97, 193201 (2006).

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