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Exotic Molecules in the Laboratory and Interstellar Space

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Fourier transform microwave spectroscopy of supersonic molecular beams has developed into a remarkably sensitive technique for studying unstable molecules. It has proven particularly effective for the detection of the kind of large reactive carbon chains often found in space, such as polyynes, radicals, and carbenes, whose rotational spectra are greatly simplified at the very low rotational temperature that is readily achieved in a supersonic molecular beam source. Although laboratory detection remains challenging, the rotational spectra of many new carbon, silicon, and sulfur molecules in various states of ionization have been detected, including a number which possess ring, ring-chain, trapezoidal, or even bicyclic structures. Precise molecular geometries have been determined by means of isotopic substitution for nearly one-half of the newly found molecules. On the basis of the laboratory data, more than 10% have been detected in space and, with large radio telescopes under construction or the discovery of better astronomical sources, it is possible that nearly all may eventually be found. This talk will provide a broad overview of our recent work, illustrating with a few specific examples the power of our laboratory techniques, and how these techniques can be applied to challenging problems in astronomical spectroscopy. Many of the results are of general interest to the chemical physics community, providing new information on molecular structure, chemical bonding, and isomeric distributions.