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Millimeter/Sub-millimeter Spectroscopy: Revealing the Building Blocks of Complex Molecules in Space

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At present, over 125 different chemical compounds have been detected in the interstellar medium. The majority of these molecules have been identified on the basis of their pure rotational spectrum, which can be measured using radio/millimeter astronomy. The success of these astronomical observations relies on the availability of high resolution laboratory data. Hence, our knowledge of the "molecular universe" has its basis in the laboratory. Over the past twenty years, studies of interstellar molecules have revealed that there is far more molecular material than previously thought in the Galaxy. Unusual species are often detected, such as the metal cyanide species MgCN and AlNC. Other molecules observed are routinely used in the organic lab, such as acetone and even a simple sugar, glycolaldehyde, CH_2OHCHO. The common appearance of organic molecules and simple species with a metal center suggest that the building blocks of life may have actually originated in interstellar space. Evaluating the limits of chemical synthesis in interstellar gas requires extensive laboratory measurements. Such measurements, however, often involve studying transient radicals and ions that are difficult to create. Such molecules can exhibit complex patterns arising from fine and hyperfine structure. Even "simple" organic species have complicated spectra due to internal rotation and multiple conformers. Using a combination of millimeter/sub-millimeter direct absorption techniques, velocity modulation spectroscopy, and Fourier transform microwave methods, the Ziurys group have been actively measuring the pure rotational spectra of potential interstellar molecules. Among the species studies are those containing cosmically-abundant metals, in particular ions such as $FeCO^+$ and TiF^+. Other molecules of interest are "prebiotic" compounds such as $HOCH_2COCH_3$. The challenges of these types of measurements will be presented , as well as their implications for astrophysics.