CARBON CHAINS, CARBON RING-CHAINS, AND CARBON CLUSTERS

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Some of the most exciting, current problems in science, including the discovery of the soccer ball molecule C_{60}, have come directly from laboratory studies of molecules known or thought to occur in space. With the radio discovery of OH some 30 years ago and the subsequent identification of more than 120 astronomical molecules, we now know that the interstellar medium is a fascinatingly rich source for many familiar and exotic species; many more can probably be found if rest frequencies can be measured in the laboratory. Laboratory detection has proved challenging, but recently good progress has been achieved by applying Fourier transform microwave spectroscopy to supersonic molecular beams of reactive species. During the past three years we have detected the rotational spectra of many new carbon chains, carbon rings, and silicon-carbon clusters. Almost all are highly polar, and several possess either unusual carbon ring-chain or bicyclic structures. The largest molecule so far detected is a polyyne chain ($HC_{17}N$) with 19 atoms and a molecular weight of 219 amu. On the basis of the laboratory data, five chains and one ring have already been detected in space, including the largest interstellar molecule $HC_{11}N$ and ring, rhombodial SiC_3.

The detection sensitivity of the present microwave spectrometer is still very far from fundamental limits set by modern technology, and an increase of an order of magnitude or more may be possible with liquid helium cooling, cryogenically cooled ultra-low-noise amplifiers, and other refinements. Such improvements may enable laboratory detection of new carbon molecules, including large molecular ions, planar and polycyclic rings, and other molecules which by symmetry are generally nonpolar. Many of our carbon molecules almost certainly have low-lying isomers that can be detected with the present techniques, and most chains are produced in sufficient abundance in our molecular beam that detection of their electronic spectra should be possible with standard laser fluorescence and absorption spectroscopies.