The Detection and Synthesis of Large and Very Large Interstellar Molecules

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Interstellar molecules with six or more atoms are often referred to as "complex" organic molecules, or COMs, even though they are certainly not complex by the standards of organic chemistry [1]. Better adjectives to describe these molecules are "large" and "very large." The large molecules are those with up to 13 atoms in size, whereas the "very large" molecules include PAH's and, more specifically, fullerenes. The large organic molecules can be subdivided into unsaturated carbon chains and more terrestrial-like species similar to solvents in the terrestrial organic laboratory. Until recently, it was thought that the different classes of large molecules belonged to different sources based on the dominant mode of synthesis. New observations however have thrown this dichotomy into disarray, and new theoretical and laboratory results have shown that the synthesis of large and very large molecules can occur via a variety of methods under different conditions. These different mechanisms, including a variety of gas-phase and grain-surface reactions, will be discussed. The rebirth of neutral-neutral chemistry, outbursts, and grain bombardment by cosmic rays will be emphasized, as will possible syntheses of very large molecules [2,3].

How can we observe larger molecules than seen up to now? The relative merits of rotational, vibrational, and electronic spectroscopy will be discussed. One advantage of rotational spectroscopy is that the spectral frequencies are directly related to the geometry of the molecule. To detect molecules with significantly more than 13 atoms will probably require lower frequency observations that customary these days because of larger moments of inertia. Difficulties in observing molecules at lower frequencies require larger surface areas, such as will be available with the Square Kilometer Array (SKA) and the extended/refurbished Very Large Array (VLA). Infrared spectroscopy can also be of use despite atmospheric opacity. The new James Webb Space Telescope will be launched within a year, and allow infrared astronomers to search for less abundant molecules albeit with a not very high spectral resolution. The SOFIA aircraft has much higher spectral resolution, but may be limited to more abundant species. Finally, the use of visible and UV spectroscopy, which probe electronic transitions, is probably limited to diffuse clouds or borders of denser regions. In a sense, observations in the visible have already been undertaken and have given us the diffuse interstellar bands, which are still mainly unassigned.

References

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