Astrochemistry: Across Disciplines & Over the Spectrum

John H. Black
Onsala Space Observatory, Chalmers University of Technology, SWEDEN

Interstellar clouds play a central role in cosmic evolution because they are the sites of formation of stars and planets and because they are the reservoirs of material that has been processed through previous generations of stars. Interstellar clouds also provide a useful focus for discussions of laboratory astrophysics. They can be observed throughout the electromagnetic spectrum, from low radio frequencies to the gamma rays that arise in cosmic-ray-induced pion decay. Although cold, molecular clouds are among the least energetic phenomena in astronomy, they depend upon energetic interactions with photons and cosmic rays for much of their heating and chemical activity.

A few examples of molecules and processes will be used to illustrate the broad scope of current research and the connections between interstellar clouds and other phenomena in space and in the laboratory. The H_3^+ ion is now observable in interstellar clouds through its infrared absorption lines. Its spectrum and the dissociative recombination process have provided numerous challenges in both experimental and computational laboratories. The excitation of H_3^+ and H_2D^+ in strongly irradiated molecular clouds is of growing interest, thus renewing the demand for cross sections for inelastic and reactive collisions with H_2. Of course, H_3^+ continues to be a valuable probe of the ionospheres of the giant planets.

The OH radical is quite versatile: it provides cosmic masers in the microwave spectrum, it is a chemical tracer of disturbed molecular gas, and recent results from *ISO* show a rich mixture of absorption and emission spectra. Its vibration-rotation spectrum is of interest for stellar opacities and for abundance analyses. Although its airglow spectrum interferes with ground-based astronomical spectroscopy in the infrared, these lines can be used for wavelength calibration and even for remote sensing of the 90 km region of the atmosphere. Other radicals (e.g. CH) and reactive molecular ions (notably CH^+ and CO^+) have recently been detected in nebular boundaries and may provide valuable insight into the interactions of UV radiation with gas, dust and large molecules like PAHs.

High-frequency radio line surveys of interstellar clouds place increasing demands on laboratory spectroscopy. Even more, observations in the submillimeter region probe gas in which low-frequency vibrations of large molecules are excited: this raises new requirements for transition moments and collisional cross sections, as well as traditional spectroscopic data. At the same time, infrared observations are revealing in more detail the connections between solid and gaseous material and highlighting new needs for laboratory data.

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