Submillimeter Spectroscopy of Astrophysically Important Metal-Containing Molecules

Aldo J. Apponi, Lucy M. Ziurys, Philip M. Sheridan,
Matthew A. Brewster, & Chandra Savage
The University of Arizona, Departments of Chemisty and Astronomy

During the past twenty-five years of molecular astrophysics, over one hundred different chemical compounds have been identified in the interstellar gas, primarily using techniques of radio and millimeter wave astronomy. The detection of such species and their subsequent use as tracers of the dense interstellar medium has lead to significant advances in our understanding of star formation, galactic structure, evolved stars, and even cosmology. An overwhelming factor in the success of molecular astrophysics is the ability to unambiguously identify a particular species on the basis of its pure rotational spectrum.

With the advent of SOFIA and Herschel, new spectral windows will be opened for spectroscopy in the submillimeter region. To conduct science in this band, laboratory measurements must be carried out to provide transition frequencies for molecular identification and physical interpretation. We are presently conducting such measurements using gas-phase submm direct absorption techniques. Of interest are simple molecules containing iron-peak elements, and metal hydride molecules (MH^+), of which many possess favorable transitions in the submm band, and thus often require space-born platforms for their observation.

Recently, we have measured the pure rotational spectrum of FeN ($X^2\Delta_i$), CrN ($X^4\Sigma^-$, and CrO ($X^5\Pi_r$). These radicals were created by the reaction of metal vapor with either N_2 or N_2O. Data for all three molecules were analyzed with an appropriate Hamiltonian and highly accurate spectroscopic constants determined, including Λ- type doubling and hyperfine constants when possible (Sheridan & Ziurys 2002; Sheridan *et al.* 2002).

Metal diatomic carbides are also of astrophysical interest. In the past year, we have detected the rotational spectrum of NiC ($X^1\Sigma^+$) and CoC ($X^2\Sigma^+$) (Brewster and Ziurys 2001). These species were synthesized by reacting metal vapor with CH_4 in a d.c. discharge. Again, highly accurate spectroscopic parameters were established from these data.

Finally, metal hydride ions are under pursuit in our laboratory as well, particularly species such as MgH^+, AlH^+, and FeH^+. For these, a new spectrometer system is being developed that employs velocity modulation—a technique sensitive to only signals arising from ionic species. The spectrometer is nearly complete, and tests are currently underway.

References:

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