FAR-INFRARED LASER MAGNETIC RESONANCE

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We have extended FIR LMR to the 400 cm^{-1} region (12 THz.) by developing a high finesse FIR cavity that permits many new short wavelength lines to oscillate. At these shorter wavelengths, we have been able to measure many atomic and molecular fine structure spectra in Al, P^+, N^+, F^+, Si, S, Fe, Fe^+, and FO.

We have also observed bending transitions of poly-atomic free-radicals: FeD_2, CCN, HCCN, and DCCN. This opens up the highly sensitive technique of FIR LMR to many new species, and provides accurate frequencies of these species for radio astronomical searches for them.

The FO radical, with a dipole moment of only 4.3 milliDebye, has never been observed in the microwave region. The highly sensitive technique of FIR LMR has sufficient sensitivity to permit the observation of the magnetic dipole fine-structure spectra of FO with an excellent signal to noise. The spectra have all been analyzed, and a value of -196.108686(50) cm^{-1} for the value of A_0 has been determined along with values for rotational, centrifugal distortion, spin-orbit, lambda-doubling, magnetic hyperfine and Zeeman terms.

Bending spectra have been recorded permitting accurate determinations of the band origins of 221.14321 cm^{-1} for the $^5\Pi_3 \leftarrow {}^5\Delta_4$ band and 226.060 cm^{-1} for the $^5\Phi_3 \leftarrow {}^5\Delta_2$ band of FeD_2. The band origin for the CCN (010) $\mu^2\Sigma^- \leftarrow$ (000) $\tilde{X}^2\Pi_r$ transition is 179.5988176(67) cm^{-1}.

A new LMR spectrometer with 20 times more power is under construction and sensitivity comparisons with the previous FIR LMR spectrometer will be shown. In preliminary tests with the new pumping geometry 20 times more power was obtained and two lines at close to 400 wavenumbers oscillated. We must now search for many of the new short wavelength transitions in methanol to fill some of the spectral gaps where very few lines existed. A beam-splitter coupled double output might even improve the sensitivity more by balancing the noise in a differential detection scheme.

Far-infrared LMR has been used to measure the Zeeman spectra of 71 free-radicals up to now. Many more species remain to be measured in the future.