Microwave Spectra: The Hyperfine Structure of Ammonia*

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April 2, 1947

USING a 12-meter wave-guide cell, a sensitive detecting system, and a pressure of approximately 10^{-5} mm Hg, we have re-examined[1] $N^{14}H_3$ spectra in the region of 1.25 cm, with the result that the small satellites of certain of the lines first detected by Good[1] are strikingly resolved. The upper curve in the accompanying photograph (Fig. 1) is a cathode-ray scope display of the 3,3 line[2] with its satellite pairs on opposite sides. These satellites are believed[3] to be a splitting of the center line by the nuclear quadrupole moment of N^{14}. The wide separation of the satellite pair which are only about 0.6 Mc apart, illustrates the remarkable resolution now obtainable with electronic techniques in the microwave region. We have also made photographs showing the similar splitting in the 1,1; 2,2; 4,4; 5,5; 6,6; and 8,8 lines.[2] The lower curve in the figure shows that obtained for the 6,6 line. The satellites are closest to the center line for the 1,1 case and move out from the center line as the quantum numbers of angular momenta increase. Accurate measurements of their positions[4] are being made and will be reported later. The intensity of the satellites, as compared with that of the center line, decreases with increasing quantum numbers of angular momenta. We have not yet photographed the fine structure of the 7,7 and 9,9 lines because our oscillator would not operate in their regions. We observed several strong lines for which J and K are unequal but did not detect any satellite structure.[3]

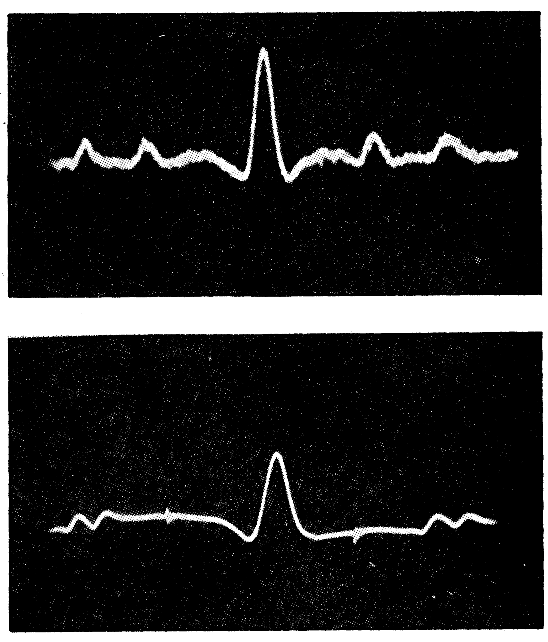

FIG. 1. Upper curve: 3,3 line of ammonia with satellite structure. Lower curve: 6,6 line, with satellite structure. Pressure $\approx 10^{-5}$ mm of Hg.

In this work we did not observe the broadening caused by saturation which was reported by Townes.[1] The sharp lines shown in the photographs were observed when approximately 10 milliwatts of power were flowing through the cell.

These results were obtained by a single crystal, unbalanced detecting system which we have evolved. In brief, we use a slowly changing reflector voltage to modulate the source and a low frequency filter in the amplifier so that the indicator does not respond to the gradual change of voltage over the envelope of the oscillator mode but is very sensitive to the abrupt changes in output caused by the sharp absorption lines. This system has the additional advantage that spurious signals caused by reflections are largely eliminated, since they are usually much broader than the absorption lines of a gas at low pressure. Our tests indicate that this system is superior to the balanced detectors which employ either two crystals and cancellation in the video stage or a single crystal and cancellation in the r-f stage.

* This research was supported by a Frederick Gardner Cottrell Special Grant from the Research Corporation and by a loan of equipment from the Office of Research and Invention, United States Navy.

[1] C. E. Cleeton and N. H. Williams, Phys. Rev. **45**, 234 (1934); B. Bleamy and Penrose, Nature **157**, 339 (1946); W. E. Good, Phys. Rev. **70**, 213 (1946); C. H. Townes, Phys. Rev. **70**, 665 (1946); M. W. P. Strandberg, R. Kyhl, T. Wentink, Jr., and R. E. Hillger, Phys. Rev. **71**, 326 (1947).

[2] Strandberg, Kyhl, Wentink, and Hillger (reference 1) and W. E. Good and D. K. Coles (Phys. Rev. **71**, 383 (1947)) have provided accurately measured frequencies of the centers of the first six of these lines.

[3] B. P. Dailey, R. L. Kyhl, M. W. P. Strandberg, J. H. Van Vleck, and E. B. Wilson, Jr., Phys. Rev. **70**, 984 (1946); D. K. Coles and W. E. Good, Phys. Rev. **70**, 979 (1946).

[4] Dailey, Kyhl, Strandberg, Van Vleck, and Wilson (reference 3) have measured the satellite separations for the 1,1; 2,2; 3,3; and 4,4 lines.

Bond Distances in OCS from Microwave Absorption Lines

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April 8, 1947

THE rotational absorption line for the $J=1$ to $J=2$ rotational transition of the OCS linear molecule was reported by Dakin, Good, and Coles.[1] Absorption at higher pressures caused by the transition had been reported previously by Hershberger.[2] The absorption line reported above was caused by the molecule composed of the abundant isotopes: carbon 12, oxygen 16, and sulfur 32. Of these three elements, only sulfur has another isotope with an abundance of more than 1 percent of the total naturally occurring element. The sulfur isotope 34 has an abundance of about 3 percent. It was believed that the sensitivity of our microwave absorption apparatus described by Good,[3] with a wave-guide absorption cell 36 feet long, was just about enough to detect the absorption line caused by the OCS molecule with the sulfur 34 isotope, and after a preliminary calculation of the approximate frequency of this line, using the bond distances reported by Cross and Brockway,[4] it was searched for and eventually found. The resolution of this isotopic absorption line was

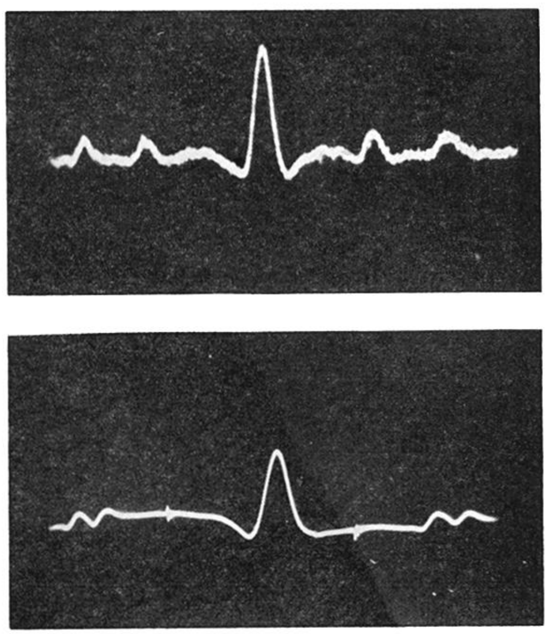

FIG. 1. Upper curve: 3,3 line of ammonia with satellite structure. Lower curve: 6,6 line, with satellite structure. Pressure $\approx 10^{-5}$ mm of Hg.