V. MICROWAVE SPECTROSCOPY

Prof. M. W. P. Strandberg   J. G. Ingersoll   I. H. Solt, Jr.
B. F. Burke   H. R. Johnson   P. R. Swan, Jr.
K. F. Cuff   J. D. Kierstead   P. A. Tate
C. F. Davis, Jr.   D. W. Posener   M. Tinkham

A. ZEEMAN EFFECT

The matrix elements for the rotational magnetic moment of a general $^1\Sigma$ molecule have been derived by Eshbach and Strandberg (1). These matrix elements involve both the real and imaginary parts of the elements of the gyromagnetic tensor, and connect states of different J and K. By applying the Wang transformation, which factors the unperturbed reduced energy matrix into four submatrices, considerable simplification is obtained: the first-order terms involve only the diagonal elements of the gyromagnetic tensor. These elements correspond to the g factors associated with rotations about the principal inertial axes of the molecule. The technique enables one to express the first-order Zeeman effect for a $^1\Sigma$ molecule in terms of these three parameters; and it is possible to transform the gyromagnetic tensor from one set of axes to another. Hence, the magnetic moment of any isotopic modification of the molecule can also be determined. If the gyromagnetic tensor of either molecule is diagonal, the complete gyromagnetic tensors of both molecules can be expressed in terms of the diagonal elements of either.

Zeeman measurements made by Jen (2) on the molecules H_2O and HDO have been repeated and extended to additional lines of HDO. The principal inertial axes of the molecule H_2O should coincide with the principal axes of the gyromagnetic tensor, hence the tensor is diagonal. Thus, the first-order Zeeman effect for rotational lines of both molecules should be expressible in terms of three parameters. These parameters can be so chosen as to yield theoretical values of the effective g factors which are in agreement with the experimental results for the five absorption lines measured so far.

The method previously reported (3) for determining the sign of nuclear magnetic moments by simultaneous Stark-Zeeman measurements appears to be doubtful; further study of the problem is required.

B. F. Burke

References

1. J. R. Eshbach, M. W. P. Strandberg: Rotational Magnetic Moments of $^1\Sigma$ Molecules, Technical Report No. 184, Research Laboratory of Electronics, M.I.T. Jan. 9, 1951

2. C. K. Jen: Phys. Rev. **81**, 197, 1951

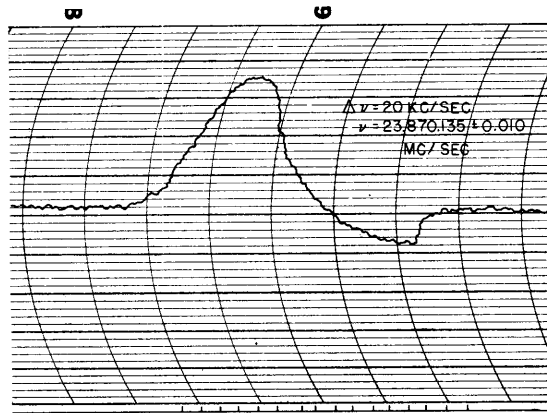3. Quarterly Progress Report, Research Laboratory of Electronics, M.I.T. Oct. 15, 1951, p. 20

Fig. V-1

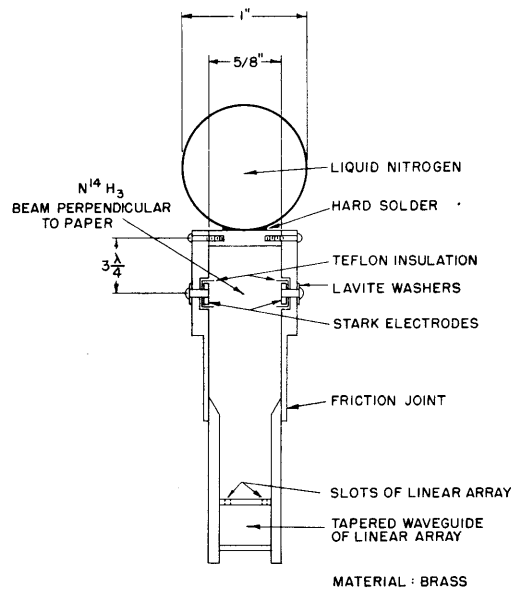Recording of absorption line obtained with beam system.

Fig. V-2

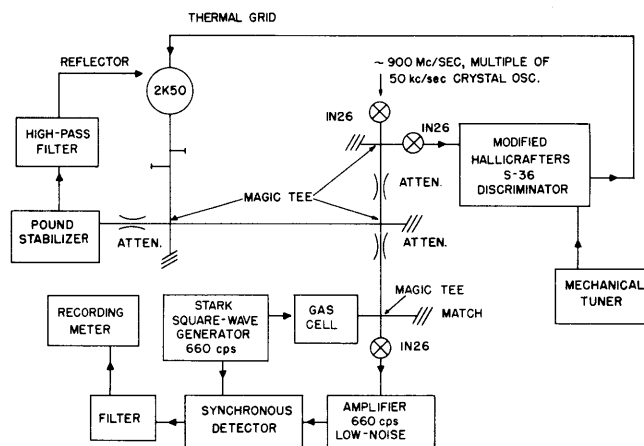Schematic cross section drawing of gas cell.

Fig. V-3

Block diagram of detection and frequency stabilization systems.

determined by a quartz crystal oscillator operating at 50 kc/sec. The automatic frequency control was accomplished with a modified Hallicrafters S-36 frequency modulation receiver whose discriminator voltage was applied to the thermal tuning grid of the 2K50. Since this discriminator voltage was quite noisy, simultaneous reduction of audio frequency modulation of the klystron was reduced with a modified Pound (4) stabilizer connected to the reflector. The modification consisted of inserting a high-pass RC filter in the path of the correction signal to the reflector. Thus, long-term stability was determined by the quartz crystal oscillator and the cavity thermal-drift problem was eliminated, but audio frequency modulation was reduced as in the Pound system.

The line widths obtained were not as small as expected because the sensitivity of the detecting system was not great enough. Work is being continued.

H. R. Johnson, M. W. P. Strandberg

References

1. G. Newell, R. H. Dicke: Bull. Am. Phys. Soc. 25, No. 5, 9, 1950

2. G. Newell, R. H. Dicke: Phys. Rev. 83, 1064 L, 1951

3. S. Silver: Microwave Antenna Theory and Design, McGraw-Hill, New York, p.328 1949

4. R. V. Pound: R.S.I. 17, 490, 1946

C.   AMMONIUM CHROME ALUM AT LOW TEMPERATURES

An attempt was made to correlate experimental data and theoretical calculations on ammonium chrome alum at 77°K. The experimental data consisted of observed microwave absorptions at a constant frequency as a function of magnetic field. These microwave absorptions were observed at various angles of the crystalline axes with respect to the magnetic field. The theoretical calculations were based on a first-order perturbation of the ground state at the free Cr^{+++} ion (^4F), due to 1) a potential of cubic symmetry, 2) a crystalline Stark field and 3) the magnetic field. Correlation was based on the assumption that the faces of the alum crystal remain interchangeable below the transition at 80°K. This correlation proved unsuccessful.

A piece of equipment has now been constructed to study the spectrum at different frequencies. It is hoped that the pattern will be simpler at frequencies closer to the Stark splittings. This apparatus is potentially capable of much more accurate orientation of the crystals in the magnetic field. Additional work on dilute crystals will be made in an attempt to obtain an explanation of the mechanism at the low temperature transition.

<div align="right">C. F. Davis, Jr.</div>