Saturation Effects in the Microwave Spectrum of Ammonia

ROBERT KARPLUS*
Mallinckrodt Chemical Laboratory, Harvard University, Cambridge, Massachusetts
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ELSEWHERE in this journal a theory of saturation effects in microwave spectroscopy is presented.[1] Recently Bleaney and Penrose published the results of an experimental investigation of saturation of the ammonia (3, 3) line in a resonant cavity.[2] The semiclassical argument which was used to analyze the data led to the conclusion that the mean time between collisions effective in restoring thermal equilibrium is 75 percent greater than the mean time between collisions that interrupt the radiation and absorption processes.

Comparison of reference 1, Eq. (36) with reference 2, Eq. (7a) shows that the calculation of Bleaney and Penrose may be used, provided it is applied to each Zeeman component individually. The (saturated) absorption coefficients are then added to give the saturated absorption coefficient of the entire line.

The ammonia (3, 3) line has six active components whose intensity is equal in pairs:

$$|P^M|^2=\mu_0^2\frac{K^2M^2}{J^2(J+1)^2}=\frac{1}{16}\mu_0^2M^2 \quad M=0,\ \pm1,\ \pm2,\ \pm3.$$

In the notation of Bleaney and Penrose, therefore, there will be three saturation parameters a' that describe the behavior of the line; they may be denoted by $a'_{|M|}$ with a corresponding relative saturation $(\alpha/\alpha_0)_{|M|}$. The $a'_{|M|}$ are

$$a_1'=(1/4)a'; \quad a_2'=a'; \quad a_3'=(9/4)a'$$

in terms of the a' used by Bleaney and Penrose (p. 94),

$$a'=\frac{0.63}{P_{mm}^2}\left(\frac{\delta_1}{\delta_0}\right)=\frac{0.63}{P_{mm}^2}\frac{1}{(1+0.17\times10^4\alpha)^2}$$

at the higher power level studied. In Table I the calculations and comparison with experiment are summarized.

TABLE I.

p(mm)	α(cm^{-1})	a'	$(\alpha/\alpha_0)_1$[a]	$(\alpha/\alpha_0)_2$[a]	$(\alpha/\alpha_0)_3$[a]	$(\alpha/\alpha_0)_{\text{theory}}$	$(\alpha/\alpha_0)_{\text{exp.}}$[a]
0.6	7.35×10^{-4}	0.34	0.99	0.94	0.87	0.90	0.90
0.4	6.1	0.95	0.97	0.84	0.69	0.75	0.75
0.3	4.8	2.13	0.91	0.69	0.54	0.61	0.58
0.2	2.85	7.24	0.72	0.46	0.30	0.37	0.33
0.1	0.61	50.4	0.34	0.14	0.06_4	0.10	0.08

[a] The figures listed here were obtained by calculation from the graph in reference (2), Fig. 3.

Since the agreement is satisfactory, one may conclude that the same collisions interrupt the radiation process and restore thermal equilibrium.

* U. S. Rubber Company, Predoctoral Fellow.
[1] Robert Karplus and Julian Schwinger, Phys. Rev. 73, 1020 (1948).
[2] B. Bleaney and R. P. Penrose, Proc. Phys. Soc. 60, 83 (1948).

On the Fine Structure of $^4\Sigma$-States of Diatomic Molecules

A. BUDÓ AND I. KOVÁCS
Department of Theoretical Physics, University of Budapest, Budapest, Hungary
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THE influence of the spin-orbit coupling on the multiplet structure of the $^4\Sigma$-states was investigated. It can be shown that this coupling gives for the four energy levels expressions identical in form with those we obtain[1] by assuming spin-spin interaction and coupling between the angular momentum $\vec{K}$ and the total spin $\vec{S}$ of the molecule.[2] This result is analogous with that found for $^3\Sigma$-states.[3] Details will be published in the Hungarica Acta Physica.

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[2] H. A. Kramers, Zeits. f. Physik 53, 422 (1929), J. H. Van Vleck, Phys. Rev. 33, 467 (1929).
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On the Phenomenology of Ferromagnetic Resonance

D. POLDER
H. H. Wills' Physical Laboratory, University of Bristol, Bristol, England
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A FERROMAGNETIC material, magnetized up to its saturation value M_0 by means of a constant magnetic field, shows interesting resonance phenomena when small additional high frequency magnetic fields are applied. We have found that in the case of an isotropic magnetic material a phenomenological description can be given by assuming that in Maxwell's equations those parts of the vectors B and H which are periodic in time (frequency $\omega/2\pi$) are related in the following way (exponential time factors being omitted):

$$B_x=\mu H_x-j\beta H_y,$$
$$B_y=\mu H_y+j\beta H_x,$$
$$B_z=H_z,$$

where z is the direction of the permanent magnetization and μ and β can be complex quantities. With the aid of classical equations of motion for the magnetic dipoles, such as have been used by Landau and Lifshitz[1] and Kittel,[2] it can be shown that, if we neglect damping terms, μ and β are real quantities given by:

$$\mu=(\gamma^2H_iB_i-\omega^2/\gamma^2H_i^2-\omega^2), \quad \beta=(4\pi M_0\gamma\omega/\gamma^2H_i^2-\omega^2),$$

where γ is the gyromagnetic ratio of the magnetic spins and H_i and B_i are the (constant) magnetic field strength and magnetic induction inside the material due to the constant magnetizing field. It may be emphasized that it is undoubtedly incorrect to interpret experimental results by means of a complex isotropic μ only.

With the aid of these relations, all results obtained by Kittel[3] and Snoek[4] for the behavior of ferromagnetic ellipsoids in a constant magnetic field on which small alternating fields are superposed can easily be derived.