V. MICROWAVE SPECTROSCOPY*

Prof. M. W. P. Strandberg
Prof. R. L. Kyhl
Dr. R. A. McFarlane
Dr. G. J. Wolga
Patricia A. Andre
J. M. Andrews, Jr.
P. H. Carr
P. C. Clapp
W. J. C. Grant
J. G. Ingersoll
E. C. Ingraham
J. D. Kierstead
M. S. Lipsett
D. W. Oliver
W. J. Schwabe
J. R. Shane
J. D. Stettler
Winifred F. Tank
N. Tepley
A. H. Thiele
M. T. Uy
S. H. Wemple
R. M. White
R. M-C. Wu

A. RUBY LINEWIDTH

Measurements of the dependence of the paramagnetic resonance linewidth in ruby have been carried out. These measurements are interesting in that they are made absolute by comparing the resonant susceptibility of the ruby with the resonant susceptibility of molecular oxygen, which can be precisely computed. By this means, the concentration of chromium ions can be determined, and the accompanying linewidth measured.

The significance of these results in the design of maser amplifiers and in our understanding of the sources for the line-broadening process in crystals is discussed elsewhere (1).

M. W. P. Strandberg

References

1. Research on Paramagnetic Resonances, Tenth Quarterly Progress Report on Signal Corps Contract No. DA36-039-sc-74895, Research Laboratory of Electronics, M.I.T., Nov. 15, 1959 - Feb. 15, 1960, p. 17.

B. PARAMAGNETIC-RESONANCE EXPERIMENTS ON SAMPLES WITH APPRECIABLE ELECTRIC LOSSES

The problem of optimizing sample size and configuration for highest sensitivity requires careful consideration when the sample has an appreciable dielectric loss tangent at microwave frequencies. A typical case in which this problem arises is encountered when paramagnetic ions are investigated in aqueous solution. For a given set of spectrometer variables, such as amplifier gain, time constant, power level, modulation amplitude, and magnetic susceptibility, the sensitivity will depend (1) on the product $Q_o\eta_{mag}$, where Q_o is the unloaded cavity Q but includes wall losses, and η_{mag} is the magnetic filling factor for the particular transition. When a lossy sample is used the relevant product is $Q_o'\eta_{mag}$, where

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$$\frac{1}{Q_o'} = \frac{1}{Q_o} + 4\pi\chi_e''\eta_e$$

in which χ_e'' is the imaginary part (loss term) of the electric susceptibility, and η_e is the electric filling factor.

This product was investigated with particular reference to the types of cavities used in the Microwave Spectroscopy Laboratory (RLE), especially to those used with water samples. The optimum values for volumes of aqueous samples are: 0.02 cm^3 for the cylindrical TE_{011} cavity; 0.03 cm^3 for the rectangular TE_{101} cavity.

G. J. Wolga

References

1. M. W. P. Strandberg, M. Tinkham, I. H. Solt, Jr., and C. F. Davis, Jr., Recording magnetic-resonance spectrometer, Rev. Sci. Instr. 27, 596-605 (1956).

C. GAIN BANDWIDTH IN CIRCUITS WITH NEGATIVE L AND C

A network-theory analysis has been made of gain-bandwidth limitations for single-cavity maser amplifiers by making use of the negative inductance and negative capacitance properties (1) of the inverted quantum-mechanical resonance. This analysis parallels the work of Fano (2) on passive networks. In the narrow-band high-gain limit the result is

$$\frac{1}{\pi}\int \ln \underline{G}^{1/2}\, d\omega = \frac{1}{2}\Delta\omega_{para}\left[\left(1+3f\chi''_{max}\omega_o/\Delta\omega_{para}\right)^{1/3} - 1\right]$$

where $\underline{G}^{1/2}$ represents voltage gain as a function of angular frequency ω; $\Delta\omega_{para}$ and ω_o refer to the natural linewidth and transition frequency of the paramagnetic resonance; χ''_{max} is the peak value of the absorptive component of susceptibility; and f is a cavity filling factor.

For broadband networks with square bandpass of width $\Delta\omega$, the result can be given in closed form:

$$f\chi''_{max}\,\omega_o/\Delta\omega_{para} = A + A^2 + \frac{1}{3}A^3\left[1 + \left(\frac{\pi}{\ln \underline{G}^{\,1/2}}\right)^2\right]$$

where

$$A = \frac{\Delta\omega}{\Delta\omega_{para}}\,\frac{1}{\pi}\ln \underline{G}^{1/2}$$

The analysis is exact only for Lorentz-shaped lines. Full details of the analysis are given elsewhere (3).

R. L. Kyhl

References

1. R. L. Kyhl, Maser circuits with negative L and C, Quarterly Progress Report No. 56, Research Laboratory of Electronics, M. I. T., Jan. 15, 1960, pp. 83-88.

2. R. M. Fano, Theoretical limitations on the broadband matching of arbitrary impedances, J. Franklin Inst. 249, 57 (January 1950); 139 (February 1950).

3. Research on Paramagnetic Resonances, Tenth Quarterly Progress Report on Signal Corps Contract No. DA36-039-sc-74895, Research Laboratory of Electronics, M. I. T., Nov. 15, 1959 - Feb. 15, 1960, p. 1.