A new spectrometer is now under construction which is expected to yield improved resolution with much higher counting rates. It is hoped that the new apparatus will permit one to make measurements of absolute gamma-ray intensities in addition to measurements of the sort described here. Such absolute measurements will require determinations of the constants of the apparatus and the efficiency of the radiator for pair production.

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** Tekniska Hogskolan, Stockholm, Sweden.
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Microwave Spectra and Zeeman Effect in a Resonant Cavity Absorption Cell*

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A MICROWAVE spectroscope has been constructed with a gas-filled resonant cavity instead of the wave guide currently used. The particular cavity tested here is of a type ordinarily used as an X-band wave meter. Such a large cavity gives a sufficiently high Q-value (i.e., long equivalent path length) and decreased effects of intensity saturation, when operated at K-band frequencies. When it is placed in an arrangement containing a Klystron source and a linear frequency sweep, there results an oscilloscopic display of a sharp cavity resonance curve. By tuning the cavity resonance to a spectral line at a sufficiently low pressure, a picture such as that shown in Fig. 1 is obtained.

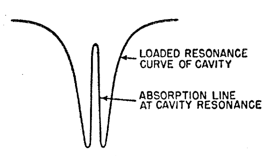

FIG. 1. Absorption line in cavity resonance.

The sensitivity of this method is enough to detect the nuclear hyperfine structure of ordinary ammonia lines of quantum numbers $JK=11$, 22, 33, 44, 55, 66, and 77.

In attempting to increase the sensitivity of the apparatus the author has tried the method originated by Dr. W. D. Hershberger,[1] in which the reflector grid of the Klystron tube is frequency modulated by a 100-kc source, in addition to the low frequency sweep, and the detected output is amplified by a narrow-band receiver at the modulating frequency or its second harmonic. The resulting sensitivity is increased to such an extent that even the nuclear hyperfine lines seem to be almost as strong as the main lines without modulation.[2] By this method we have also confirmed many of the weaker lines of SO_2 found by Professor E. B. Wilson's group (to be published).

With the aid of the frequency-modulation scheme, the Zeeman effect for microwave spectral lines has been observed with a cavity, specially constructed out of a non-magnetic cylinder and magnetic end plates acting as pole pieces, by applying an axial magnetic field up to 3000 gausses. In agreement with the results of Coles and Good[3] each absorption line of ammonia is split into a doublet. In the case of a cavity, a doublet is observed for a mode which has the microwave electric field perpendicular to the external magnetic field (TE modes), and a triplet for a cavity mode which has components both perpendicular and parallel to the magnetic field (TM modes).

Still more interesting is the fact that all the nuclear hyperfine lines of ammonia have been split by the magnetic field into doublet or triplet components in essentially the same way as the main lines themselves. A typical spectral diagram for a TE mode is shown in Fig. 2.

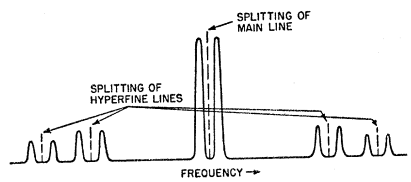

FIG. 2. Zeeman splitting of an NH_3 line and its hyperfine structure.

Measurements of the Zeeman separation as functions of the magnetic field strength and the quantum numbers of the spectral lines for ammonia and other gases are in progress.

My thanks are due Mr. S. P. Cooke and other members of the Microwave Group in this Laboratory for valuable discussions and technical help, and to Professor E. B. Wilson, Jr., for much advice.

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The Neutron-Scattering Cross Section at the Cadmium Resonance

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THE existence of slow neutron-scattering resonances was shown experimentally in 1944 by A. Langsdorf.[1,2] They have since been studied with neutron-filter methods by Wollan *et al.*,[3] Dancoff and Lichtenberger,[4] and Fermi and Marshall.[5] Independently, Goldhaber *et al.*[6,7] found a strong scattering resonance in manganese.

The scattering cross section at the cadmium resonance has recently been measured using a beam of neutrons from a single crystal monochromator.[8] The energy spread of the neutrons was about one quarter of the width of the resonance ($\Gamma=0.115$ ev).[9] A sheet of cadmium 0.056 cm thick, whose surface made an angle of 24° with the beam, scattered neutrons into a boron-lined counter. The counter subtended about 15 percent of the 4π solid angle. Scattered neutrons making angles between 35° and 160° with the forward direction could be detected. The geometry was calibrated using an iron scatterer for which $\sigma_{\text{scat}}{}^{10}=10.3\times10^{-24}$ cm^2.

Counting rates were very low. Despite bulky shielding of the counter and scatterer the scattering was small compared to the fast neutron background in the pile room. It seems probably that a complete scattering resonance could not be measured in a reasonable time without extensive redesign of the shields and counters.

A total of 5372 counts from the cadmium and 5040 background counts were recorded during equal counting times. Corrections were made for the scattering of higher energy neutrons in the beam, for air scattering, and for absorption of scattered neutrons by the scatterer itself. The scattering chamber was lined with cadmium to eliminate double scattering from the beam to the chamber walls and into the counter. The cross section was found to be $40\pm15\times10^{-24}$ cm^2 referring to the normal isotopic mixture. Approximately half the indicated error is the probable error from the counting statistics. The other half represents an uncertainty in the corrections. Only the correction for absorption by the scatterer was large. It was not calculated more accurately because of the large and somewhat poorly defined solid angle subtended by the counter.

Recent work[9] has shown that the cadmium total resonance is accurately fitted by a one-level Breit-Wigner formula with $E_R=0.176$ ev and $\sigma_T=7200\times10^{-24}$ cm^2. Cd^{113} (abundance 12.3 percent, spin $\frac{1}{2}$) is known[11] to be the active isotope. If the spin of the compound nucleus is known, these data permit a calculation of the resonance-scattering cross section. Conversely, if the scattering cross section is measured, the spin may be determined.

The following equation,[12] valid when the scattering is small compared to the absorption, relates the quantities in question.

$$\sigma_S=\frac{\sigma_T{}^2}{f_A}\frac{E_R}{1.3\times10^{-18}\left(1\pm\dfrac{1}{2i+1}\right)}.$$

σ_T is the maximum total cross section at a resonance, and σ_S the maximum elastic scattering cross section at the same resonance. Both cross sections are measured in cm^2 and refer to the normal isotopic mixture. E_R is the energy of the resonance in electron volts, f_A is the fractional abundance of the active isotope, and i is its spin. The plus or minus sign in the denominator is to be used accordingly as J, the spin of the compound nucleus, is i plus or minus one-half. One calculates from this equation $\sigma_S=114\times10^{-24}$ cm^2 if $J=0$, and $\sigma_S=38\times10^{-24}$ cm^2 if $J=1$. To each of these must be added a potential scattering cross section[9] of 5.3×10^{-24} cm^2.

The comparison of the measured and calculated cross sections is not seriously complicated by crystal effects. Because of the spin and low isotopic concentration of Cd^{113}, more than 90 percent of the predicted Breit-Wigner resonance scattering will be isotropic. The potential scattering depends on the properties of all the isotopes, and a larger fraction might be expected in the Bragg reflected component. These considerations introduce smaller uncertainties than arise from the measurement of the cross section. They do not affect the conclusion that the scattering is in satisfactory agreement with the assignment $J=1$ to the compound nucleus and in definite disagreement with $J=0$.

I wish to thank Mr. W. Sturm and Mr. G. Arnold for their assistance with the spectrometer and Mr. R. Sternheimer for several helpful discussions on coherence and incoherence in neutron scattering. The following formula, relating the isotropic part of the resonance-scattering cross section to that calculated from the Breit-Wigner relations, is from an unpublished investigation of Mr. Sternheimer's.

$$\sigma_{\text{isotropic}}=\left[1-\frac{2J+1}{2(2i+1)}f_A\right]\sigma_S.$$

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* On leave from the University of Wisconsin.

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Rotors Driven by Light Pressure*

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In a series of experiments[1] on the production of very intense centrifugal fields it was found that the frictional drag on a magnetically suspended spinning spherical rotor could be accounted for almost entirely by gaseous friction even when the pressure surrounding the rotor was as low as 10^{-6} mm Hg. For example, when a magnetically supported 1.59-mm rotor spinning at about 100,000 r.p.s., in air at a pressure of 2×10^{-6} mm Hg, was allowed to "coast" (without the driving torque applied) it required about an hour for it to lose 0.1 percent of its rotational speed. The existence of this exceedingly low frictional torque suggested that it might be possible to drive magnetically suspended rotors in a good vacuum by light pressure directed tangentially on the periphery of the rotor. It is well known that the pressure of sunlight is roughly 4.5×10^{-5} dyne per cm^2 at the surface of the earth. Consequently, if a few cm^2 of sunlight directed tangentially on