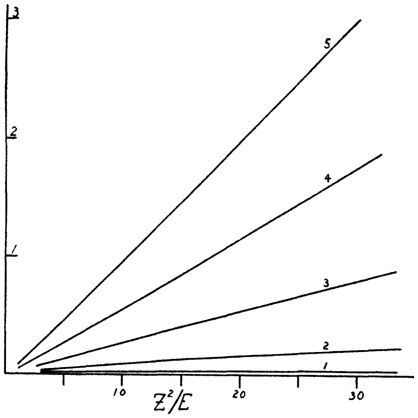

FIG. 2. Curves for the ratio of the magnetic internal coefficient for the L_{III} sub-shell to those for the L_I sub-shell as a function of Z^2/E.

versus Z^2/E for $Z=35$ and E, the gamma-ray energy in kev, were given for multipole orders $l=1$, 2, 3. The calculations have been extended to cover multipole orders 4 and 5. Figure 1 shows the complete set of curves. For the sake of comparison, the curves of Hebb and Nelson[2] for the electric multipole conversion ratios are included.

In Fig. 2 the ratio of the magnetic internal conversion coefficients for the L_{III} sub-shell to those for the L_I sub-shell has been plotted against Z^2/E for $Z=35$. Since, in this approximate theory, the magnetic internal conversion for the L_{II} sub-shell is less than 5 percent of that for the L_I sub-shell, these curves provide an additional method for determining the type of magnetic multipole radiation.

The curves of Figs. 1 and 2 are valid for low Z and low gamma-ray energy. However, the exact calculations of Rose and his co-workers[3] show that, in the K shell, the approximate method gives very poor results for the internal conversion coefficients for Z as low as 40 and energies as low as 150 kev. Of course, if one is concerned with lower values of Z, say about 25, and smaller gamma-ray energies, better agreement of approximate with exact calculations may be expected. In any case it is possible that the ratios given by the approximate method may be better than the values of the internal conversion coefficients. This point will be settled when the exact calculations for the L shell are completed. Until then the curves should be used with extreme caution.

* Deceased.
[1] I. S. Lowen and N. Tralli, Phys. Rev. **75**, 529 (1949).
[2] M. H. Hebb and E. Nelson, Phys. Rev. **58**, 486 (1940).
[3] M. E. Rose *et al.* Phys. Rev. (to be published).

A New Gyromagnetic Effect

S. J. BARNETT AND LOUIS A. GIAMBONI
University of California, Los Angeles, California, and California Institute of Technology, Pasadena, California
September 30, 1949

THE existence of this effect was suggested to one of us by Professor Albert Einstein a number of years ago. Not long afterward the quantitative theory was developed, and experiments instituted to test its validity. Circumstances, however, made it necessary to stop the work temporarily before it was completed, and only recently has its continuance become practicable, with the same magnetic materials and much the same experimental procedure, but with great improvements in many particulars.

A long circular cylinder of the substance under investigation is magnetized along its axis to intensity of magnetization J_z near saturation, so that the moments of all the magnetic elements point essentially in the same direction, Z.

In a direction X, normal to Z, a small magnetic intensity with frequency f, much below the resonance frequency, is applied. When the rod is absent the intensity in the space it is to occupy is

$$H_x = H_{0x} \sin 2\pi ft.$$

This causes the intensity of magnetization (always practically parallel and equal to J_z) to oscillate through the small angle θ in the plane XZ, thus producing a small intensity of magnetization J_x, synchronous with H_x and proportional thereto. The angle θ is given by the relation

$$\theta = J_x/J_z.$$

The rotation of the elements gives rise to a gyromagnetic intensity in the rod in the direction Y (normal to X and Z) such that[1]

$$H_y = \rho d\theta/dt$$

where ρ is the gyromagnetic ratio.

If the rod is infinite in length, there results an intensity of magnetization in the direction Y given by the formula

$$J_y = \rho f/2\pi \cdot [(\mu-1)/(\mu+1)]^2 (H_{0x} \cos 2\pi ft)/(J_z)$$

where μ is the transverse permeability of the material.

From this formula, after correction for end effects due to the finite length of the cylinder, and after direct measurements of J_z and the other quantities involved, the quantity ρ can be calculated. It is assumed that, as is the case of the actual experiments, eddy currents are negligible.

In this way, for compressed Permalloy powder (from the Bell Telephone Laboratories), at frequencies of 22 kc and 30 kc, and in longitudinal fields varying in strength from 0 to 2700 gausses, it has been found that the (corrected) formula is satisfied throughout the region of approximate saturation when

$$\rho = (1.01 \pm 0.06) m/e.$$

The formula does not, of course, hold in the region between $J_z=0$ and approximate saturation. As would be expected, J_y is zero when J_z is zero; and it increases to a maximum somewhat before approximate saturation is reached. It then follows the formula into the strongest fields.

In view of the magnitude of the experimental error, there is no certain disagreement between these results, obtained with very intense fields, and the results obtained from the Barnett effect, with rotation frequencies equivalent to exceedingly minute magnetic intensities, and from the Einstein-de Haas effect, with weak and moderate intensities. This value is about $1.05\, m/e$.[2]

Experiments have also been made on compressed iron powder (from the Bell Telephone Laboratories), but the fields obtainable have not been sufficiently intense to produce approximate saturation. The observable early part of the curve between J_y and J_z closely resembles that for Permalloy, and the part nearest saturation suggests a value of ρ approximately equal to $(1.06 \pm 0.10) m/e$. The standard value of ρ for iron is $1.03 m/e$.[2]

We expect to publish soon a much more nearly complete account of this work.

For important assistance we are indebted to the Carnegie Institution of Washington, the National Research Council and the U. S. Navy, ONR. The experimental work has been done in the Norman Bridge Laboratory of the Institute.

[1] S. J. Barnett, Phys. Rev. **6**, 239 (1915); and Proc. Am. Acad. **68**, 229 (1933).
[2] S. J. Barnett, Proc. Am. Acad. **73**, 401 (1940); Proc. Am. Acad. **75** 109 (1944); and Phys. Rev. **66**, 224 (1944).