Gyromagnetic Ratio of Cobalt

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Magnetomechanical measurements were made on two cobalt rods in an attempt to find changes in the g' factor at low magnetic intensities. No such effect was found, g' being independent of the induced magnetic intensity down to the lowest values which could be measured.

The results also indicate that cobalt samples of high purity would be required in order to obtain an accurate value of g' for this metal.

INTRODUCTION

IT has recently been shown that the gyromagnetic ratios for Fe, Ni, and the FeNi alloy series, are field-dependent for weakly magnetized specimens.[1] A similar investigation for cobalt showed no such effect down to the lowest values of magnetic intensity at which it was possible to make measurements with the present equipment. Two different cobalt rods were used and approximately 12 000 individual observations of amplitude change were made over a period of three months.

RESULTS

The cobalt rods used in this investigation were the same as those used in previous work.[2] The experimental apparatus and techniques have also been described.[1,3] The condensed data for the two cobalt rods are presented in chronological order in Tables I and II. Values of $\rho e/m$ and g', averaged for each of the magnetic intensities used, are given in Table III, and plotted in Fig. 1. Also, in Fig. 1, both the g' and $\mathscr{I}$ values for the two rods have been averaged for each value of the magnetizing current used. It can be seen from this plot that g' does not change its value for weakly magnetized specimens as was the case for Fe, Ni, and the FeNi alloys.

TABLE I. Values for the gyromagnetic ratio of cobalt arranged in chronological order. Each value obtained from a set of 240 amplitude observations. [International Nickel Company (IN) specimen.] i_e = magnetizing current, milliamperes; M_e = total magnetic moment, amp cm^2; ρ = gyromagnetic ratio, gram coulomb^{-1}; e/m = specific electronic charge, coulomb gram^{-1}.

i_e	M_e	$\rho e/m$	i_e	M_e	$\rho e/m$
8.00	19 488	1.088	8.00	19 487	1.083
8.00	19 487	1.079	8.00	19 486	1.096
4.00	8552	1.088	2.00	3830	1.092
4.00	8552	1.097	10.00	25 288	1.091
2.00	3830	1.089	10.00	25 283	1.090
2.00	3830	1.098	2.00	3830	1.080
6.00	13 817	1.088	6.00	13 817	1.087
6.00	13 815	1.088	13.00	34 229	1.083
4.00	8553	1.093	13.00	34 226	1.087
10.00	25 290	1.091	16.00	43 187	1.080
10.00	25 284	1.092	16.00	43 183	1.088
4.00	8552	1.097	16.00	43 186	1.082
13.00	34 230	1.087	16.00	43 184	1.088
13.00	34 227	1.087	6.00	13 818	1.093

[1] G. G. Scott, Phys. Rev. **99**, 1241 (1955); **99**, 1824 (1955); **103**, 561 (1956).
[2] G. G. Scott, Phys. Rev. **87**, 697 (1952).
[3] G. G. Scott, Phys. Rev. **82**, 542 (1951).

DISCUSSION

The average of all of the individual values for g' for the International Nickel Company cobalt specimen is 1.837±0.002. For the General Motors Research

TABLE II. Values for the gyromagnetic ratio of cobalt arranged in chronological order. Each value obtained from a set of 240 amplitude observations. [General Motors (GM) specimen.] i_e = magnetizing current, milliamperes; M_e = total magnetic moment, amp cm^2; ρ = gyromagnetic ratio, gram coulomb^{-1}; e/m = specific electronic charge, coulomb gram^{-1}.

i_e	M_e	$\rho e/m$	i_e	M_e	$\rho e/m$
10.00	26 408	1.083	2.00	3895	1.074
13.00	35 436	1.083	2.00	3895	1.069
13.00	35 431	1.069	4.00	8874	1.053
6.00	14 503	1.070	4.00	8874	1.051
6.00	14 502	1.077	6.00	14 502	1.084
2.00	3895	1.073	6.00	14 502	1.064
8.00	20 434	1.083	4.00	8874	1.091
8.00	20 433	1.062	4.00	8874	1.097
10.00	26 418	1.064	8.00	20 433	1.097
4.00	8875	1.051	8.00	20 433	1.081
4.00	8874	1.082			

TABLE III. Summary. Values of $\rho e/m$ and g' averaged for each value of the magnetic intensity used in these experiments on cobalt. $\mathscr{I}$ = average induced magnetic intensity of rod amp cm^{-1}; $\mathscr{I}=(M_e-i_e\Sigma A_e)/v$ where v = volume of rod; $v=38.57$ cm^3 for rod A; $v=36.83$ cm^3 for rod B; $i_e\Sigma A_e$ = magnetic moment of winding, amp cm^2.

i_e	$\mathscr{I}$	$\rho e/m$	g'
A. International Nickel Company cobalt specimen			
2.00	95.7	1.090	1.835
4.00	214.1	1.094	1.828
6.00	346.7	1.089	1.837
8.00	489.9	1.086	1.842
10.00	636.3	1.091	1.833
13.00	862.4	1.086	1.842
16.00	1088.9	1.084	1.845
B. General Motors cobalt specimen			
2.00	101.7	1.072	1.866
4.00	231.8	1.071	1.868
6.00	387.9	1.074	1.863
8.00	536.4	1.081	1.851
10.00	694.1	1.074	1.864
13.00	932.0	1.076	1.859

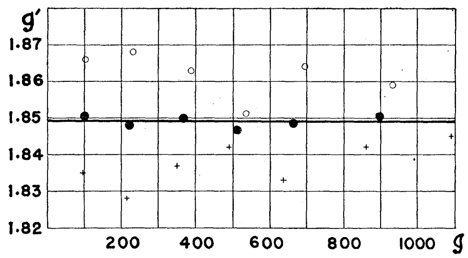

FIG. 1. Plot of g' *vs* intensity of magnetization for cobalt. Open circles are values obtained for General Motors rod. Crosses are values obtained for International Nickel Company rod. Solid circles obtained by averaging, for each value of the magnetizing current used, the g' and $\mathcal{J}$ values for the two rods.

cobalt specimen, the average value for g' is 1.862 ± 0.005. The magnetomechanical measurement of the gyromagnetic ratio of cobalt has always been more difficult than similar measurements for other metals. However, the precision of this work is such that the 1.4% difference between the g' values for these two rods cannot be accounted for on the basis of accidental error.

It will be noted by referring to reference 2 that each of these rods had impurity contents of over 1%. It is considered probable that difference in this impurity content is the cause of the 1.4% difference in the g' values. If this is correct, g' values for slightly impure samples of cobalt could be considerably different from the true value for the pure metal. In this case the true g' value for cobalt could only be obtained with samples of a much higher degree of purity than those used in these experiments.

CONCLUSIONS

The results of this series of experiments on cobalt show that the gyromagnetic ratio of this metal is independent of the intensity of magnetization, within the range of intensity values used. The results also indicate that the true value of g' for cobalt could only be found by using specimens of high purity. It is hoped that in the future opportunity may present itself to investigate further the effect of small amounts of impurity on the gyromagnetic ratio of this metal.

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High-Frequency-Induced Electroluminescence in ZnS

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A brief presentation of data is given for electroluminescent measurements made on several ZnS crystals over a frequency range of 1 cps to 370 Mc/sec. Electroluminescent relaxation becomes apparent in the order of 10^5-10^6 cps. A simple exponential equation, $I=A(V-V_0)^B$, was found to fit the time-average electroluminescent intensity *vs* voltage over four decades of intensity.

ELECTROLUMINESCENCE in ZnS has been measured with excitation frequencies ranging from 1.0 cps to 370 Mc/sec. Thin, flat, conductive crystals, about 2 mm on a side, were used. The experimental apparatus is described elsewhere.[1] Measurements of the voltage threshold of time-average light output as a function of frequency are shown in Fig. 1. It should be pointed out that threshold data are a reciprocal function of the usual frequency-dependent data obtained at constant voltage. The former may be regarded as more fundamental for wide frequency excitation, since high excitation, particularly at high frequencies, produces considerable heating. This in turn may produce inconsistent or misleading results.[2,3] At no time during the threshold measurements did the temperature rise exceed 2°C above the constant ambient, as measured by a thermocouple attached to the crystal body. The data for single crystals are approximated by a series of straight lines on log-log paper. This method of presentation, however, was not used since it resulted in confusion due to vertical compression. At very low frequencies the single-crystal curves approach the dc threshold values and there is some correlation between the low-intensity luminescent decay time and low-frequency flattening of the curves. This decay time was not significantly different following dc or high-frequency excitation. It is apparent that electroluminescent relaxation processes become significant at about 10^5-10^6 cps.

In addition, the time-average light output *vs* voltage has been measured at dc and at high frequencies over a

[1] G. G. Harman (to be published).
[2] G. F. Alfrey and J. B. Taylor, Brit. J. Appl. Phys., Suppl. No. 4, S44 (1955).
[3] C. H. Haake, Phys. Rev. **101**, 490 (1955).