Faraday Effect in Cerium Phosphate Glasses at Low Temperatures

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The Faraday effect in glass specimens containing cerium metaphosphate in various concentrations has been measured at 4.2°K and 1.8°K, using 5461 A light, in magnetic fields ranging to 70 kilogauss. The curves of rotation *vs* H/T were fitted to the Brillouin function for $J=\frac{1}{2}$, yielding values of $g=1.75$ and $\beta=0.874$ Bohr magneton. The observed rotations were quite large; for the glass containing the highest concentration of cerium, the rotation approached a saturation value of 4.76π radians/mm.

THE Faraday effect exhibited by a group of cerium phosphate glasses at helium temperatures has been measured in magnetic fields ranging to 60 kilogauss. The optical rotations observed were quite large and were proportional to the amount of cerous ion present in each specimen. The data were analyzed in terms of the theory of paramagnetism and a value of g was calculated.

The glass specimens were kindly furnished by Dr. N. J. Kreidl of the Bausch and Lomb Optical Company. They were composed of a mixture of cerous metaphosphate, $Ce(PO_3)_3$ and a barium phosphate, expressed as $Ba(PO_3)_2$. Four samples were used in this work; they contained, respectively, 20%, 50%, 80%, and 100% cerous metaphosphate by weight. The rotations were measured at two temperatures, 4.2°K and 1.8°K, and the 5461-A line of mercury was used for illumination. The magnetic fields were provided by a water-cooled solenoid.

The experimental results are shown in Fig. 1. The data have been plotted to show the rotation experienced by the plane of polarization of the incident light upon traversing 1.0 mm of glass.

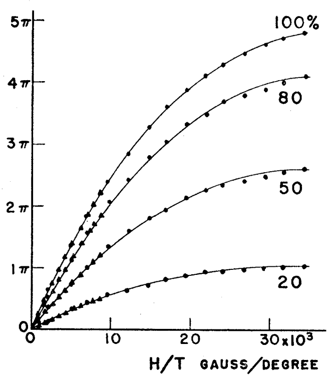

FIG. 1. Faraday rotations produced by specimens of cerous metaphosphate glass 1.0 mm thick. The points marked by (▲) were taken at 4.2°K; thos marked by (●) were taken at 1.8°K. Percentages shown refer to nominal cerium content.

Following a method of analysis due to J. Becquerel and recently reviewed by van den Handel,[1] the rotation, θ, was fitted to an equation of the form

$$\theta=A\tanh(\mu H/kT)+BH, \qquad (1)$$

where A and B are constants, μ is a magnetic moment, and the other symbols have their usual meanings. The value of μ was found to be the same for all specimens, and had the value

$$\mu=0.874 \text{ Bohr magneton.}$$

The values of A were nearly proportional to the nominal percentages of cerous metaphosphate given for each sample. The 100% specimen showed the largest departure from strict proportionality, being about 5% low. This can be attributed to oxidation of some of the cerous (Ce^{3+}) ion to ceric (Ce^{4+}) during the manufacture of the glass.

For the 100% sample, the constants were

$$A=4.76\pi \text{ radians,}$$
$$B=1.2\pi\times10^{-6} \text{ radian/gauss.}$$

As can be seen, the contribution of the B term remained very small even at 60 kilogauss.

If we consider the optical rotation observed in a given specimen to be proportional to its magnetization, we can identify the tanh term in Eq. (1) with the Brillouin function, $B_J(gJ\beta H/kT)$, which reduces to the hyperbolic tangent for $J=\frac{1}{2}$. If β is taken to be the Bohr magneton, then the value of μ quoted above allows us to calculate a value of g. For the glasses investigated here, g has the value

$$g=1.75.$$

Since g remains the same over a wide range of compositions, we may conclude that the cerium ions remain relatively independent of each other. This conclusion is strengthened by the fact that the rotations observed at 4.2°K fall on the same curve as those observed at 1.8°K, when the data are plotted as a function of H/T.

Because of this apparent absence of interactions in the liquid helium range, it is possible that the glasses would be useful for magnetic cooling experiments. In addition, their high sensitivity suggests application to studies of the structure of the intermediate state in superconductors.

[1] J. van den Handel, *Encyclopedia of Physics* (Springer-Verlag, Berlin, 1956), Vol. 15, p. 1.