ev/atmosphere calculated from changes in Hall constant is more representative of the true shift in energy gap since it is independent of changes in mobility. Since mobility equals the Hall constant divided by the resistivity, the mobility of InAs decreases with increasing hydrostatic pressure.

I am indebted to Dr. Robert Talley and Mr. Frank Stern of the U. S. Naval Ordnance Laboratory, Silver Spring, Maryland for providing me with samples and many helpful discussions. I should like to thank Donald Long of the University of Pennsylvania, Department of Physics for his informative assistance.

PHYSICAL REVIEW VOLUME 100, NUMBER 6 DECEMBER 15, 1955

Magnetic Properties of Erbium Metal*

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(Received August 3, 1953; revised manuscript received August 31, 1955)

Measurements of the magnetic moment of erbium metal in the temperature range from 20.4°K to 90°K are reported. The initial susceptibility shows a maximum at 78°K and the metal appears to become ferromagnetic near 20°K.

NEEL,[1] working with the magnetic data of Klemm and Bommer,[2] has predicted a Curie point for erbium at about 40°K. Barson's[3] work on the electrical resistivity of erbium has shown an anomaly at about 80°K. This type of anomaly in the electrical resistivity has been shown to be closely associated with magnetic phenomena in gadolinium[3–5] and dysprosium.[3,6,7] This paper describes the results of investigations of some of the magnetic properties of erbium metal.

The metal used in this study was prepared by methods

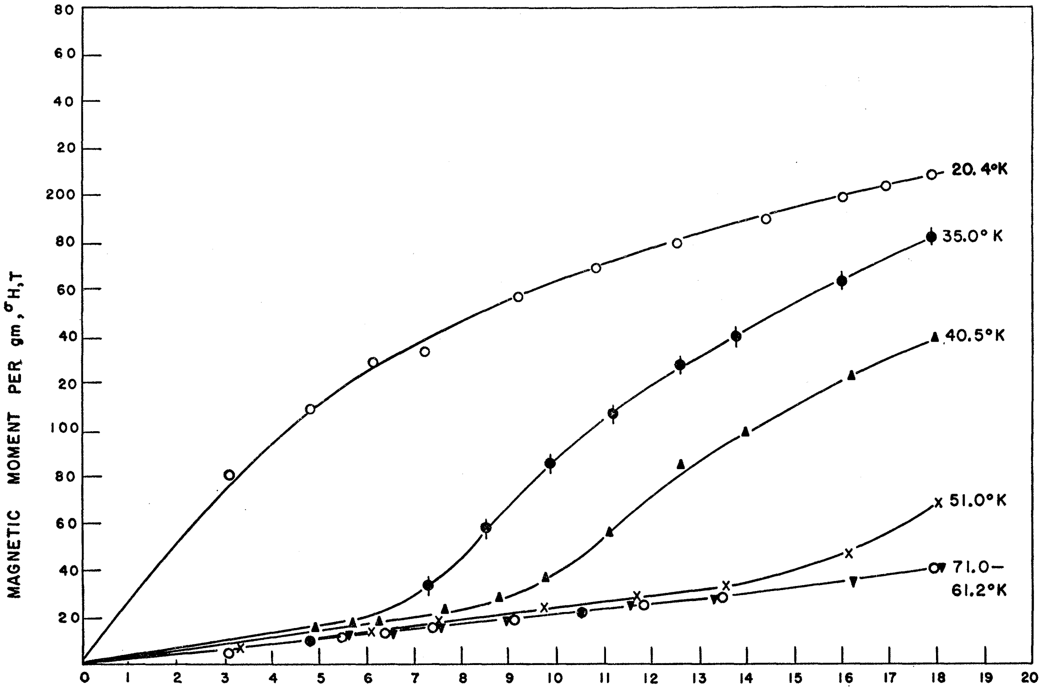

Fig. 1. Magnetization isotherms of erbium metal.

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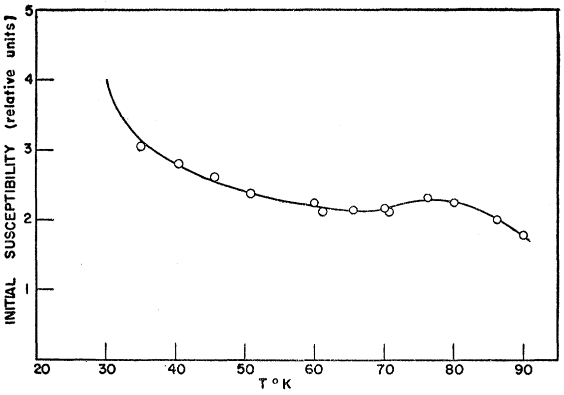

FIG. 2. The initial susceptibility of erbium as a function of temperature.

previously reported.[8,9] Spectrographic analysis showed the sample contained the following impurities: calcium, detectable but less than 100 ppm; yttrium, detectable but less than 100 ppm; iron, detectable but less than 2000 ppm; nickel, cobalt, and other rare earths not detected. These quantities of impurities are maximum upper limits as complete spectrographic standards for determining accurate quantitative amounts of impurities in erbium were not available.

The experimental procedure was similar to that used to measure the magnetic properties of gadolinium and is described elsewhere.[10,4]

Figure 1 shows several of the magnetic isotherms for erbium. Above about 75°K the isotherms are linear for applied fields up to 18 000 oersteds. From about 60°–75°K, the isotherms are linear for low fields, but show evidence that the susceptibility is slightly field-dependent for fields above 15 000 oersteds. As the temperature is lowered below 60°K, the susceptibility becomes strongly field-dependent and this occurs at lower and lower applied fields. At the hydrogen point, erbium seems to have ferromagnetic properties, as indicated by spontaneous magnetization. The data indicate that the ferromagnetic Curie point is near 20.4°.

The initial susceptibility of erbium calculated from the low-field data of Fig. 1 is plotted as a function of temperature in Fig. 2. The magnetic anomaly at about 75°K is quite similar to the corresponding anomaly in dysprosium at 176°K[6,7] but is not as well developed.

The similarity between the magnetic behaviors of erbium and dysprosium is further evidenced by the magnetic moment *vs* $1/H$ curves of the two elements. The σ *vs* $1/H$ curve for erbium at 20.4°K is shown in Fig. 3. It is to be noted that this curve seems to consist of two intersecting straight lines as do the corresponding curves of dysprosium.[7] The extrapolation of the two straight lines to $1/H=0$ yields saturation magnetizations of about 179±5 cgs units for the low-field extrapolation and 267±5 cgs units for the high-field extrapolation at 20.4°K. The spectrographic state for the erbium ion is a $^4I_{15/2}$ and one would expect an absolute saturation moment of 9 Bohr magnetons if all the spin and orbital angular momentum contributed to the ferromagnetism. For spin only the expected moment would correspond to 3 Bohr magnetons. The high-field extrapolation of the 20.4°K data of 269 cgs units corresponds to about 8.0 Bohr magnetons.

In the period since this paper was first submitted for publication, the heat capacity of erbium metal has been measured by Skochdopole *et al.*[11] and Koehler and Wollan[12] have reported neutron diffraction data on the metal. The heat capacity shows maxima at 19.9°K, 53.5°K, and 84°K. It would seem that the maximum in the weak-field susceptibility of Fig. 2 is associated with the 84°K heat capacity maximum and that the metal has what might be called a ferromagnetic Curie temperature at 19.9°K. The neutron diffraction data indicate that the metal is ferromagnetic at 4.2°K and that in the neighborhood of 80°K the metal could be ferromagnetic or antiferromagnetic. The data reported here rule out the ferromagnetic state at 80°K.

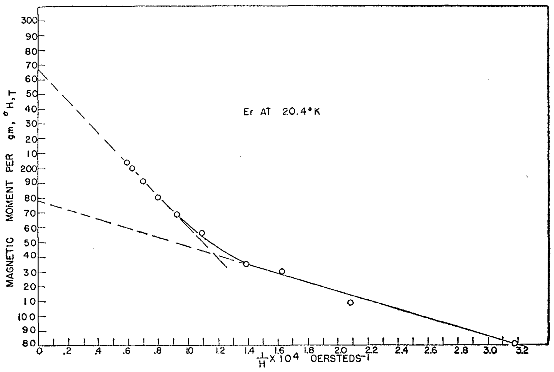

FIG. 3. The magnetic moment of erbium at 20.4°K plotted as a function of $1/H$.

Several attempts to duplicate measurements of the type reported here on different samples of erbium metal at 20.4°K have been unsuccessful. The samples appeared to have large crystallites and exhibited strong anisotropy effects. One sample turned 90° with respect to the field and another was stable at about 30° with respect to the field.

The authors wish to express their thanks to J. Powell for preparing the rare earth salts and to A. H. Daane, R. Barton, and D. Dennison for preparing the metal samples.

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