# Magnetic susceptibility of $ErH_2$: Evidence for a complex magnetic structure

Richard L. Carlin and Larry J. Krause
*Department of Chemistry, University of Illinois at Chicago, Chicago, Illinois 60680*
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The susceptibility of $ErH_2$ displays magnetic ordering at 2.6 K and remains temperature independent below that temperature. The results suggest that there may be an important ferromagnetic interaction present, though the compound appears to be a net antiferromagnet.

The specific heat of $ErH_{1.99}$ exhibits a sharp peak at $2.12 \pm 0.03$ K which has been attributed to antiferromagnetic ordering.[1] The Mössbauer spectrum of $ErH_{2.0}$ has been analyzed in terms of a $\Gamma_6$ Kramers doublet for the ground state of the erbium and a magnetic transition at $2.4 \pm 0.1$ K was reported.[2] The susceptibilities of $ErH_{1.96}$ and $ErH_{2.02}$ were measured by the Faraday method[3] above 4.2 K; although magnetic ordering was not observed, large negative (antiferromagnetic) Weiss constants of $-18$ K were reported. The existence range of erbium dihydride is $ErH_{1.86}$–$ErH_{2.13}$, and since the dihydride contains erbium in the trivalent state,[2] there is one conduction electron per metal ion in the system.

In Fig. 1, we display the zero-field ac susceptibility of a carefully prepared[4] polycrystalline sample of $ErH_{2.08}$, measured at 300 Hz. Magnetic ordering is apparent at $2.6 \pm 0.1$ K, but there are several features about the data which lead us to suggest that $ErH_2$ adopts a complex antiferromagnetic structure. The observed change in ordering temperature with composition of $ErH_{2 \pm x}$ is not unreasonable.

At first glance, the data might be thought to be

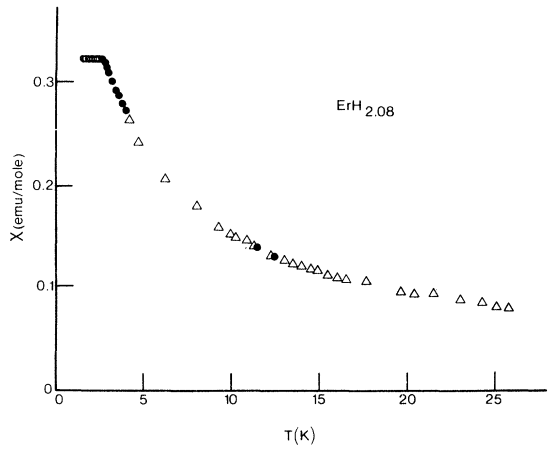


FIG. 1. Zero-field susceptibility of $ErH_{2.08 \pm 0.02}$. Different symbols refer to runs in different cryostats.

suggestive of ferromagnetic rather than antiferromagnetic ordering. Thus the shape of the data near 2.6 K does not exhibit the roundedness typically found with antiferromagnets but rather a sharp discontinuity, more like a molecular-field-controlled system. The data remain constant in value below the transition temperature, reminiscent of the demagnetization-factor-limited susceptibility of a ferromagnet. There are several reasons, however, that seem to argue against such an interpretation of the data. First of all, the antiferromagnetic sign of the Weiss $\Theta$, measured over the interval 4.2–300 K, has already been mentioned. Secondly, the shape and distribution of the particles govern the demagnetizing factor, and although both of these are irregular, one generally finds a much larger susceptibility at the onset of a ferromagnetic transition. The magnitude of the data appears to be too small—less than 0.4 emu/mole at the lowest temperature—to be attributed to the presence of a ferromagnetic moment. Weak ferromagnetism and ferrimagnetism appear to be ruled out as well, though it would be better if single-crystal data were available. The out-of-phase component of the susceptibility, $\chi''$, on the other hand, increases as the temperature is lowered to $T_c$, maximizes at $T_c$, but then decreases as the temperature is lowered further. This kind of behavior is precisely what one would expect for the movement of ferromagnetic domains. Ferromagnets frequently do show strong absorption below $T_c$, but this depends on such factors as the type of domain wall, the relaxation time, and the distribution (according to particle size) of the demagnetizing factor. Finally, this behavior differs substantially from what we have observed with antiferromagnetic $DyH_2$.[4]

We do not believe that the constant susceptibility below $T_c$ can be ascribed to a spin-flop transition. The data were obtained by the ac mutual inductance procedure in an applied field of only a few oersteds. It seems unlikely that spin flop would occur in such a small field.

The magnetic structure of terbium deuteride—actually $TbD_{1.93}$—has been reported to consist of fer-

 

romagnetic planes coupled antiferromagnetically.[5] Because of the metallic conduction in the dihydrides one can expect that the RKKY interaction is still operative, and that this long-range interaction can give rise to a complex magnetic structure. On the basis of the available data, we suggest that the magnetic structure of $ErH_2$ may be not unlike that of $TbD_2$ and worthy of further investigation by a microscopic measurement such as neutron scattering.

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