ABSENCE OF INDUCED MAGNETIC FIELDS AT Gd NUCLEI IN GdFe_2

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Measurements of the magnetic hyperfine field at ^{155}Gd in GdFe_2 in external magnetic fields reveal the absence of induced magnetic fields, in disagreement with other reported data.

The presence of large induced magnetic hyperfine fields at Gd nuclei in Gd metal and GdFe_2 has been inferred from measurements in applied magnetic fields [1]. The only feasible explanation for such large induced fields appeared to be the possibility of dramatic changes in the conduction electron polarization, caused by the external fields. Such changes, presumably, would require the introduction of an entirely new interaction mechanism.

In an attempt to elucidate the nature of the proposed interaction, we measured the hyperfine field at ^{119}Sn nuclei in dilute alloys of Sn in Gd in external magnetic fields, using recoilless resonance absorption. No contribution from induced fields was observed. We therefore remeasured the external magnetic field dependence of the hyperfine field at Gd sites in GdFe_2 by performing recoilless gamma-resonance measurements

of the 86.5 keV transition in ^{155}Gd , with a source of $\text{Sm}_{0.05}\text{Al}_{0.95}$ and an absorber of GdFe_2 . The latter was produced by arc-melting and subsequent annealing at 800°C under vacuum for a week [2]. Source and absorber were cooled to 4.2°K . A superconducting solenoid produced longitudinal magnetic fields of up to 56.6 kOe at the absorber. The stray field at the source was varied from 2.3% to 50% of the field at the absorber by changing the source position.

The observed field at the ^{155}Gd nucleus in GdFe_2 as a function of applied field (corrected for demagnetizing effects) is shown in fig. 1. With the source in low stray fields, the applied field simply adds to the hyperfine field (positive in GdFe_2), i.e., no induced fields are observed. With the source in a large stray field, an anomalously large splitting is observed, which we attribute to hyperfine structure in the source induced by large fields at low temperatures, i.e., paramagnetic hfs. The fact the splitting increases with increasing external field at the source in "anomalous" splittings if the source as well as the absorber is split. This is especially true for $2 \rightarrow 0 + \text{E2}$ transitions where a two line hyperfine pattern will be observed [1] even with both source and absorber split (if the sign and magnitude of the hyperfine interaction is the same, however, only a single line will be observed). If the source and absorber have hyperfine interactions of the same sign, a decrease in the splitting will be observed, while for hyperfine interactions of opposite sign, an increase in the splitting will be observed. For a paramagnetic Gd source, the saturation hyperfine field is negative and should be of the order of 300 kOe (for Gd^{3+} , $8S_{7/2}$, core polarization is the major contribution to the hyperfine field). This is sufficient to account for the observations of ref. 1 in GdFe_2 and Gd metal, without introducing induced fields.

We conclude that the reported anomalous splittings [1], which exceeded the applied fields by factors of the order of 5, are due to induced hyperfine splitting in the source in the stray fields and are not due to fields induced in the absorber. We note that reducing the stray field down to 20 kOe does not affect the source splitting because it is still in the saturation region of the Brillouin function.

Fig. 1. Magnetic fields H_{nuc} at Gd nuclei in GdFe_2 , plotted as a function of the external field H_{ext} , corrected for the demagnetizing field H_{dem} . The solid line corresponds to $H_{\text{nuc}} = H_{\text{hf}} + (H_{\text{ext}} - H_{\text{dem}})$. O, field at source = $0.023 H_{\text{ext}}$; Δ , field at source = $0.50 H_{\text{ext}}$.

icates that the hyperfine field in the source is negative.

In a longitudinal configuration, the polarization conditions can result in the observation of "ano-

References

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