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COMMENTS ON "PARAMAGNETIC RESONANCE TRANSMISSION IN GADOLINIUM"

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Lewis, Alexandrakis, and Carver have recently reported[1] observation of resonance signals transmitted through gadolinium foil, which they tentatively interpret as evidence for a new type of long-range magnetic order. The purpose of this note is to offer a more pedestrian explanation in terms of the so-called "ferromagnetic antiresonance," which occurs when the usual ferromagnetic dynamic permeability[2] approaches zero. This gives an increase in the skin depth and hence maximum transmission through a foil. The skin depth at the antiresonance in gadolinium should be at least 10 μ (as compared with 4 μ in the absence of magnetic effects), which should give enough transmission through the 75-μ foil to be detected by a sensitive receiver.

With the external field parallel to the sample, the antiresonance occurs[3] for $H=\omega/\gamma-4\pi M(T, H)$, if this is positive. In the perpendicular geometry, it occurs for an internal field of $\omega/\gamma-4\pi M(T,H)$ or an external field $H_{\text{ext}}=\omega/\gamma$; however, if $4\pi M(T,H)$ is made greater than ω/γ by lowering the temperature, the sample will be broken into domains at $H_{\text{ext}}=\omega/\gamma$ and the transmission will disappear. The ordinary ferromagnetic resonance might also get through in some cases by some other mechanism, e.g., magnetostrictive vibrations.

These considerations account for the position or absence of transmission peaks for all the cases reported by Lewis, Alexandrakis, and Carver.

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[1]R. B. Lewis, G. C. Alexandrakis, and T. R. Carver, Phys. Rev. Letters 17, 854 (1966).

[2]C. Kittel, Phys. Rev. 73, 155 (1948). The "ferromagnetic" expression must of course be used even above the Curie temperature, so long as $M(T,H)$ is large.

[3]The effective field from magnetocrystalline anisotropy will give a shift in single-crystal samples or a smaller shift plus broadening in polycrystals.