Comment on the Role of Spin-Nonconserving Forces in the Critical Dynamics of Fe and Ni

Recently Mezei[1] has shown with new high-resolution neutron experiments on Fe that for $T > T_C$ the linewidth, Γ_q, for wave vector q cannot be fitted with the diffusion law $\Gamma_q \sim Dq^2$ expected for spin-conserved dynamics. In addition, he found that at T_C, $\Gamma_q \sim q^{5/2}$ for $0.01 < q < 0.3$ Å^{-1}, as expected for spin-conserved dynamics.

Mezei notes that "to the contrary of what was believed, at $T = T_C$ there is no evidence for any deviation from the dynamics expected for the exchange model." For $T > T_C$, he remarks that "the dynamical scaling behavior does not apply for small q values. This is a very unexpected result, since [the spin-diffusion law] is a simple, general consequence of spin conservation."

Given hyperfine and ESR data on isotropic ferromagnets,[2,3] we regard the failure of $\Gamma_q \sim Dq^2$ as not surprising but predictable; and contrary to Mezei, we find that the neutron results not only demonstrate breakdown of spin-conserved scaling but also the existence of a substantial region of spin-nonconserved scaling. We *are* surprised by the results at T_C. We explain below.

We distinguish between the critical region, $\kappa/q \ll 1$, the intermediate region, $\kappa/q \sim 1$, and the hydrodynamic region, $\kappa/q \gg 1$ (where κ is the inverse correlation length). We note that the dynamic scaling hypothesis states $\Gamma_q = q^z \Omega(\kappa/q) = \kappa^z \Omega'(\kappa/q)$, where Ω and Ω' are scaling functions, and $z = \frac{5}{2}$ and $z = 2$ correspond to conserved and nonconserved spin dynamics, respectively.[4]

Behavior for $T > T_C$.—Here hyperfine experiments measure the spin autocorrelation time, which is an average over Γ_q^{-1} weighted toward $\kappa/q \sim 1$, whether dynamics are conserved or not.[4] For Fe and Ni we observe crossover[2] from $z = \frac{5}{2}$ at large $T - T_C$ to $z = 2$ at small $T - T_C$. For the neutron data near $\kappa/q \sim 1$ one thus expects nonconserved scaling at small $T - T_C$ and conserved scaling at large $T - T_C$. Mezei's scaling plot (his Fig. 3) confirms this.

ESR results sample $\kappa/q = \infty$, and for all isotropic ferromagnets show $\Gamma_0 \sim \kappa^2$ over two decades in κ.[2,3] They are understood via spin-nonconserved dynamics, with $z = 2$, $\Omega(x) = x^2$, and $\Omega'(x) = \text{const}$ as $x \to \infty$. Mezei's scaling plot, $\Gamma_q/q^{5/2}$ vs κ/q, is not suited for testing this picture. More appropriate is our plot of Γ_q/κ^2 vs κ/q (Fig. 1), which is consistent with spin-nonconserved scaling for $\kappa/q \gg 1$.

Behavior at T_C.—Here neutron data correspond

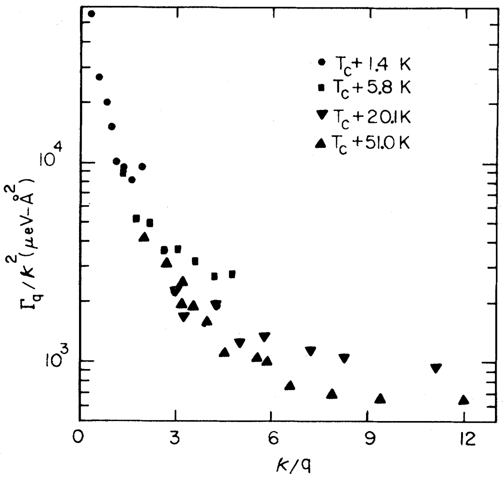

FIG. 1. Scaling plot appropriate for testing Mezei's data for spin-nonconserved scaling as $\kappa/q \to \infty$.

to $\kappa/q = 0$, and exhibit spin-conserved dynamics. Earlier,[2] arguing by analogy to dipolar materials, we predicted crossover at T_C from $z = \frac{5}{2}$ to $z = 2$ as $q \to 0$. Mezei's results surprise us, and prove this suggestion incorrect.

In conclusion, close to or at T_C spin-conserved scaling for $\kappa/q \ll 1$ coexists with spin-nonconserved scaling for $\kappa/q \geq 1$. Well above T_C spin-conserved scaling extends up to $\kappa/q \sim 1$ and higher. This picture is based on analysis of experiments and the scaling hypothesis alone, and clarifies and extends Mezei's interpretation.

Huber[5] points out that pseudodipolar interactions can explain the observed behavior.

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[1]F. Mezei, Phys. Rev. Lett. 49, 1096 (1982).
[2]C. Hohenemser, L. Chow, and R. M. Suter, Phys. Rev. B 26, 5056 (1982), and references therein.
[3]M. B. Salamon, Phys. Rev. 155, 224 (1967).
[4]B. I. Halperin and P. C. Hohenberg, Phys. Rev. 177, 952 (1968).
[5]D. L. Huber, Phys. Rev. B (to be published).