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Magnets have Two Longitudinal Degrees of Freedom

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We argue that the usual magnetization $\vec{M}$, which represents a correlated property of 10^{23} variables, but is summarized by a single variable, cannot diffuse; only the non-equilibrium *spin accumulation* magnetization $\vec{m}$, due to excitations, can diffuse. For *transverse* deviations from equilibrium this is consistent with work by Silsbee, Janossy, and Monod (1979), and by Zhang, Levy, and Fert (2002).

We examine the corresponding theory of *longitudinal* deviations for a ferromagnet using M and the longitudinal spin accumulation m. If an initial longitudinal magnetic field H has a frozen wave component that is suddenly removed, the system approaches equilibrium via two exponentially decaying coupled modes of M and m, one of which includes diffusion. If the system in a slab geometry is subject to a time-oscillating spin current, the system approaches equilibrium via two spatially decaying modes, one associated with spacial decay away from each surface. We also explore the possibility that decay of M directly to the lattice is negligible, so that decay of M must be mediated through decay to m and then to the lattice.

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