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Magnon-induced nonanalyticities in thermodynamic and transport properties of quantum ferromagnets[1] SRIPOORNA BHARADWAJ, DIETRICH BELITZ, Department of Physics and Institute of Theoretical Science, University of Oregon, Eugene, OR 97403, THEODORE R. KIRKPATRICK, Institute for Physical Science and Technology, and Department of Physics, University of Maryland, College Park, MD 20742 — Soft modes and their effects on thermodynamic and transport properties are of great interest. An example of a nonanalyticity induced by Goldstone modes is the divergence of the longitudinal susceptibility, $\chi_{\rm L}(k) \sim 1/k^{4-d}$, in a classical isotropic Heisenberg ferromagnet in $2 < d < 4$ dimensions everywhere in the ordered phase. Here we investigate the fate of this nonanalyticity in a quantum ferromagnet. Power counting at $T = 0$ suggests a weaker singularity, $\chi_{\rm L}(k) \sim k^{d-2}$, due to the additional frequency integration. We find that this term has a zero prefactor due to spin conservation. Consistent with this, a corresponding term in an antiferromagnet has a nonzero prefactor. A small but nonzero temperature restores the nonanalyticity in a ferromagnet, and the prefactor vanishes linearly with T. Similarly, magnetic impurities violate the spin conservation and lead to a nonanalytic term even at $T = 0$. We explore all of these effects by means of nonlinear sigma models for both ferromagnets and antiferromagnets, and by an effective field theory for itinerant ferromagnets, and discuss the crossover from the classical result to the $T = 0$ limit in detail.

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Sripoorna Bharadwaj
Department of Physics, Univ of Oregon

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