Spin-wave instability theory for ferromagnetic nanostructures

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A microscopic, or Hamiltonian-based, theory is outlined for studying the spin-wave instability thresholds of the parametric processes occurring in ferromagnetic nanostructures under conditions of pumping with a microwave field. Most previous work has concentrated on spheres or films with dimensions of order several microns or more, and the theoretical interpretation has been made in terms of macroscopic (continuum) methods. At smaller length scales, as in ultrathin films and nanowires with thickness or lateral dimensions less than about 100 nm, the discreteness of the quantized spin waves and their spatial distributions become modified, making it more appropriate to employ a microscopic approach to the nonlinear dynamics with a lattice of effective spins interacting through the magnetic dipole-dipole and exchange interactions. Effects of microwave pumping (in either the parallel or perpendicular configuration) are incorporated in calculations for the instability thresholds of the quantized spin-wave bands in different nanostructures and materials.