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Scattering Theory of Mesoscopic Gilbert Damping

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Magnetic damping determines the performance of magnetic devices including high-frequency oscillators, hard drives, magnetic random access memories, magnetic logic devices, and magnetic field sensors. The drive to improve these devices, to reduce the response time of sensors and the physical dimensions has led to a greater focus on studying the friction force a changing magnetization experiences. We study the magnetization dynamics of single domain ferromagnets and domain walls in contact with a thermal bath by scattering theory. We recover the Landau-Lifshitz-Gilbert equation and express the Gilbert damping tensor in terms of the scattering matrix [1,2]. Dissipation of magnetic energy equals energy current pumped out of the system by the time-dependent magnetization, with separable spin-relaxation induced bulk and spin-pumping generated interface contributions [3]. The scattering theory of Gilbert damping is suitable for first-principles calculations that include disorder and spin-orbit coupling on an equal footing [4]. In linear response, our scattering theory for the Gilbert damping tensor is equivalent with the Kubo formalism.

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