MAR09-2008-007035

Abstract for an Invited Paper
for the MAR09 Meeting of
the American Physical Society

Theory of Magnetization Relaxation in Conducting Ferromagnets

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The advent of technologically promising spintronics devices has revived efforts to achieve a microscopic understanding of magnetization damping in magnetic metals and semiconductors. In absence of an electric current, magnetization relaxation is described by the Gilbert parameter α, whose quantitative prediction relies on electronic structure calculations that treat disorder in an approximate fashion. We assess the reliability of these studies by using simple models where disorder may be treated exactly. Transport currents modify the magnetization damping. We associate this change with the non-adiabatic spin transfer torque, which is characterized by a dimensionless parameter β. We derive a concise analytical expression for β that can be applied to real materials. We also discuss the counterparts of α and β in out-of-equilibrium superconductors viewed as easy-plane ferromagnets in particle-hole space.