# Magnetic damping

Andrei Kirilyuk

*Radboud University, Institute for Molecules and Materials,*
*Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands*
a.kirilyuk@science.ru.nl

Damping of the motion of the magnetization vector, particularly the damping of the large-amplitude motion, plays a significant role both in performance of magnetic devices, and in the fundamental processes such as for example ultrafast laser induced dynamics.

In ferromagnetic media, spin motions are described commonly through use of the Landau–Lifshitz equation that contains a phenomenological parameter $\alpha$, the Gilbert damping constant. This controls the dissipation rate associated with either the small amplitude motions probed in ferromagnetic resonance (FMR) or Brillouin light scattering (BLS) studies of long wavelength spin excitations in ferromagnetic media and also that of large amplitude spin motions associated with magnetization reversals. The damping constant $\alpha$ is generally extracted from data on a particular system of interest; in most analyses, it is assumed either explicitly or implicitly that the damping rate is intrinsic to the material from which the sample is fabricated.

The aim of this lecture is to discuss the effects of basic dissipative mechanisms involved in the dynamics of the magnetization. The mechanisms may be roughly divided into direct relaxation to the lattice, and indirect relaxation via excitation of many magnetic modes. The first ones strongly depend on the nature of magnetic materials: we speak of "breathing Fermi surface" in itinerant magnets, and consider magneto-striction and magnon-phonon coupling in the localized ones.

The second type of mechanisms involves extrinsic contributions to the spin damping rate and other parameters that may control the dynamic response of magnetization. Such contributions are of great interest because they are subject to control through sample preparation, for example, to produce very narrow FMR lines. Conversely, in selected instances, one may wish to see spin motions more heavily damped. As an example of the latter case, it is desirable to suppress "ringing" of magnetization after reversal in certain devices.

## Literature:

***Breathing Fermi surface:***

L. Hodges, D. R. Stone, and A. V. Gold, *Field-Induced Changes in the Band Structure and Fermi Surface of Nickel*, Phys. Rev. Lett. **19**, 655 (1967); J. Kunes and V. Kambersky, *First-principles investigation of the damping of fast magnetization precession in ferromagnetic 3d metals*, Phys. Rev. B **65**, 212411 (2002).

***Magnetic insulators:***

V.G. Baryakhtar and A.G. Danilevich, *The phenomenological theory of magnetization relaxation (Review Article)*, Low. Temp. Phys. 39, 993 (2013)

***Extrinsic damping:***

Douglas L. Mills and Sergio M. Rezende, *Spin Damping in Ultrathin Magnetic Films*, B. Hillebrands, K. Ounadjela (Eds.): Spin Dynamics in Confined Magnetic Structures II, Topics Appl. Phys. **87**, 27–59 (2003)