Laser-Induced Ultrafast Demagnetization: Femtomagnetism, a New Frontier?

Guoping Zhang[1]*, Wolfgang Hübner[1],
Eric Beaurepaire[2], and Jean-Yves Bigot[2]

[1] Max-Planck-Institut für Mikrostrukturphysik
Weinberg 2, 06120 Halle, Germany
huebner@mpi-halle.de
[2] Institut de Physique et Chimie des Matériaux de Strasbourg, Unité Mixte 380046, CNRS-ULP-ECPM
23, rue du Loess, 67037 Strasbourg Cedex, France
jean-yves.bigot@ipcms.u-strasbg.fr

Abstract. The conventional demagnetization process (spin precession, magnetic domain motion and rotation) is governed mainly by spin–lattice, magnetic dipole and Zeeman, and spin–spin interactions. It occurs on a timescale of nanoseconds. Technologically, much faster magnetization changes are always in great demand to improve data processing speed. Unfortunately, the present speed of magnetic devices is already at the limit of the conventional mechanism with little room left. Fortunately and unprecedentedly, recent experimental investigations have evidenced much faster magnetization dynamics which occurs on a femtosecond time scale: femtomagnetism. This novel spin dynamics has not been well-understood until now. This article reviews the current status of ultrafast spin dynamics and presents a perspective for future experimental and theoretical investigations.

1 Introduction

High areal density media and fast write/read heads are two basic building elements in the recording industry [1]. High density improves data rates, which require a wider electronic transport bandwidth for the reading process and a shorter reversal time for the writing process. The major obstacle lies in the writing process. As we move to data rates above 30 MB/s (nanosecond region), it is essential to understand the time dependence of the magnetization reversal processes in magnetic materials. Indeed, different timescales yield distinctive physical mechanisms, as shown in Fig. 1. On a long timescale of 100 ps–10 ns, magnetic dipole–dipole, Zeeman, and spin–lattice interactions are the major driving forces [2]. domain wall motion and rotation are modeled phenomenologically by the classical Landau–Lifshitz–Gilbert (LLG) equation [3], where electron excitations are completely ignored. On a timescale of 1 ps–100 ps (GHz), electron–phonon, phonon–phonon and, spin–lattice interactions prevail. The classical description above gradually becomes invalid

* Present address: Department of Physics and Astronomy, The University of Tennessee at Knoxville, TN 37996-1200, USA; gpzhang@utk.edu

B. Hillebrands, K. Ounadjela (Eds.): Spin Dynamics in Confined Magnetic Structures I,
Topics Appl. Phys. **83**, 245–288 (2002)