Light-induced (de)magnetization processes and all-optical switching

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Within two lectures we will overview the impressive progress of the field of femtomagnetism. Started in 1996 by a pioneering work on ultrafast demagnetization in ferromagnetic Ni film triggered by a femtosecond laser pulses, by now femtomagnetism developed into an important chapter of condensed matter physics, which promises to pave a way towards fast and energy-efficient magnetic recording.

The lecture is split into two parts. In the first part we will discuss the ultrafast processes occurring in magnetic metals under the action of femtosecond laser pulses. We will consider the main experimental findings, such as already mentioned ultrafast demagnetization, as well as generation of spin waves, and magnetization reversal. Then we will define the main problems which researchers face when trying to explain the observed phenomena. In particular, it is still under hot debates how different subsystems of a magnetic metal (electrons, spins and lattice) react to a laser pulse impact and how the energy and angular momentum flow between these subsystems. We will discuss (on a basic level) main theoretical concepts on femtomagnetic phenomena in metals, which are developed by now. In the conclusion of the first part we will consider the all-optical magnetization reversal, the intriguing phenomenon which allows switching of magnetization in a ferrimagnet by a single femtosecond laser pulses without an applied field.

The second part will be devoted to ultrafast laser-induced phenomena in magnetic dielectrics. Here we will introduce and consider in detail the idea of ultrafast opto-magnetic phenomena, which enable one to manipulate magnetization of a medium using polarization of laser pulses and involve low or even no absorption. Next, we will discuss the approaches to control magnetization of a magnetic dielectric via laser-induced changes of magnetic anisotropy. Finally, we will discuss the examples of magnetization switching in magnetic dielectrics and the difference with the switching in metals.

References

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