Femtosecond Laser-Induced Magnetization Dynamics

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All-optical techniques exploiting femtosecond laser pulses have opened the way towards the exploration of the ultimate limits of magnetization dynamics, providing means to manipulate magnetic systems at down to femtosecond time scales. In this presentation, first a review of recent developments in the field of ultrafast magnetization dynamics will be presented. It has been found that magnetic order in ferromagnetic transition metals can be quenched within a few hundred femtoseconds after laser heating. Also the reverse effect, generation of magnetization by driving the antiferromagnetic to ferromagnetic phase transition with femtosecond laser heating has been demonstrated. The microscopic interpretation of the magnetic phenomena at the sub-ps level has remained a mystery until recently. Recent experiments, including detailed fluence dependent all-optical studies on transition metal and rare earth ferromagnets, and time-resolved X-ray magnetic circular dichroism using femto-sliced 100 fs pulses, have shine more light on the underlying physics. It will be shown that an Elliott-Yafet scenario, describing spin-flip scattering of electrons upon momentum scattering upon phonon absorption or emission, agrees quantitatively with most recent findings. Thus we have been able to explain not only the laser fluence dependence of the magnetization dynamics in materials such as nickel and cobalt, but also why demagnetization proceeds orders of magnitude faster in these materials as compared to the rare earth ferromagnet gadolinium.