Ultrafast dynamics of spins and spin currents: magnetic storage and spintronic THz emitter

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Magnetization manipulation is an indispensable tool for both basic and applied research. I will discuss some of the knobs to tune dynamics at ultrafast time scales. The dynamics of the response depends on the energy transfer from the laser excited electrons to the spins within the first femtoseconds. This determines the speed of the ultrafast magnetization: if the electrons are driven to a strong excitation density, a second slower process is found. This slowdown is a signature of the intrinsic ferromagnetic electron correlations in a ferromagnet. One possibility of control is to shape the properties of the electronic system. A special material of interest for magnetic storage development is FePt. This material allows an interesting modification of its density of states: Pt alloying increases the magnetic anisotropy and reduces the number of states at the Fermi level making it "more noble". Consequently, the electron temperature shoots to higher values above the Curie temperature (Fig.1), a precondition for all-optical writing [1,2].

On the other side due to the non-equilibrium electron distribution, also ultrafast currents are generated and contribute to the laser driven spin dynamics. Similarly, to shaping the density of states in the first example, adjacent layers of a noble metals like Pt, Au or transition metals like W, Ta, Ru can shape the THz spin currents and convert ultrafast laser-driven spin currents via the ultrafast spin-Hall effect into a charge current burst. This opens a way towards novel THz spintronic devices: optimizing thicknesses and layers, we can realize efficient metallic THz spintronic emitters of ultra-broadband terahertz radiation competing with state-of-art photo-conductive switches THz emitters used for airport security [3,4].

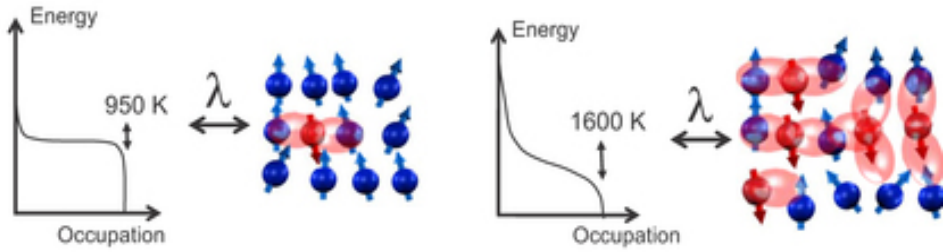

Fig1. Effect of the coupling of electron temperature to the spin system in case of a standard ferromagnet, and in comparison FePt with a small specific heat (high electron temperatures). The material becomes "critical" and more easily to write with helicity dependent fs-laser pulses.

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