Laser pulse and photon energy tuning for increased all-optical magnetization switching efficiency

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Magnetization manipulation on ever shorter time scales has been an indispensable tool and remains important for application development as well as basic research [1]. So far, optical laser pulses provide the fastest means to trigger magnetization dynamics. The ultrafast magnetization processes speed is determined by the energy transfer from the electron system to the spins. From the application point of view, granular FePt has gained special interest as media for heat-assisted magnetic recording with high coercivity and switching fields above 6 T [2]. In our approach, we use femtosecond laser pulses of two opposite helicities to directly manipulate the magnetization state and thus write information to the FePt grains, a technique, that has been applied to several magnetic materials. In our current understanding, after the ultrafast excitation and heating, the influence of magnetic dichroism together with the presence of the inverse Faraday effect jointly interact and work as forces, causing magnetization reversal. The switching rates are calculated for individual FePt nanoparticles by obtaining the optical effects (inverse Faraday effect and magnetic dichroism induced heating) from ab-initio calculations in the first step, and in the second step including those into thermal modelling of magnetization dynamics in the Landau-Lifshitz-Bloch model. This provides the switching rates for the ensembles. We can trace the different processes from the beginning of the laser pulse impact [3]. This theoretical description allows us to optimize the required number of shots to reverse the magnetization of FePt nanoparticles and pinpoints how to optimize the all-optical writing by tuning the laser fluence and wavelengths. For further understanding of the interplay between the involved processes, additional investigations are providing answers to the open questions and extending the possibilities of all-optical writing as a general mechanism. Experiments tuning the laser wavelengths, while simulatneously adjusting the fluence and pulse duration provide and insight in the behavior caused by an increase photon absorbtion and changed asymmetry for the inverse Faraday effect induces by the opposite helicities. The switching efficiency behaves in a nontrivial way, as slightly changing the experimental parameters does not automatically lead to better magnetization results.

References:

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