Purely Precessional All-Optical Femtosecond Magnetic Switching

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Ultrafast laser sources provide unique tools to control the magnetic properties of materials, both spatially and temporally. Since the pioneering work on ultrafast laser induced demagnetization [1], femtosecond (fs) laser pulses have been widely used in theoretical and experimental studies of femtomagnetism, achieving switching at the picosecond (ps) time scale [2]. Recent technological advances have made possible to harness the polarization structure of ultrashort laser beams, allowing the generation of radially or azimuthally polarized laser pulses. In particular, it has been recently proposed that Tesla-scale fs magnetic fields (*B*), isolated from the electric field (*E*), can be obtained through the use of ultrafast azimuthally polarized laser beams [3]. Such configuration offers the opportunity to perform pure magnetic interactions with an intense fs *B* field.

In this work, we numerically show that it is possible to switch any ferromagnetic material in the fs time scale using an isolated *B* field, such as that obtained from an azimuthally polarized laser pulse [4]. Up to now, most of the research has been focused on the effect of the *E* field on magnetization, especially the ability to demagnetize the magnetic ions by driving them to a non-equilibrium state, which may be done in tens of fs. Our micromagnetic simulations demonstrate that the use of intense *B* fields (up to 10^2-10^3 Tesla) obtained from an azimuthally polarized laser pulse, allows to perform ultrafast switching driven by purely precessional effects (see Fig. 1). In such scenario, the effect of the *E* field can be avoided and so the possible sample damage. Our work opens a promising scenario to achieve complete switching of a magnetic state at fs time scales through the use of structured laser beams.

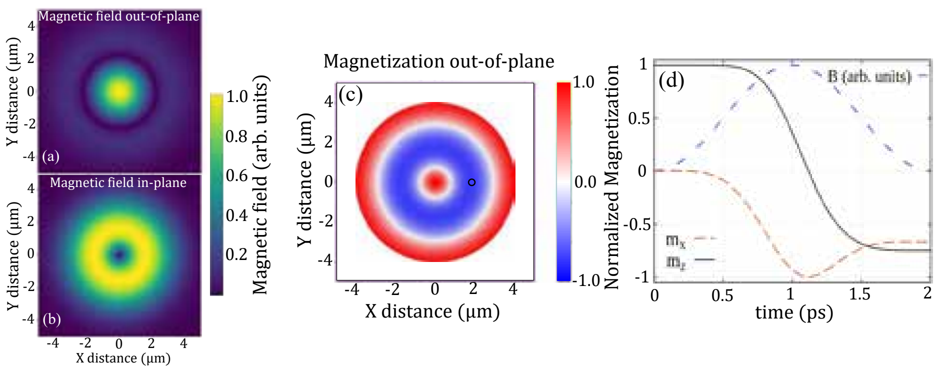

Figure 1: Spatial distribution of (a) the out-of-plane and (b) the in-plane B field carried by an azimuthally polarized laser pulse. (c) Magnetic state after the application of a 720 fs laser pulse of frequency f=200 THz. The initial magnetic state is a uniformly magnetized nanodot with a radius of *r*=2μm. (d) Temporal evolution of the magnetization at r=896 nm (black circle in (c)), showing purely precessional all-optical magnetic switching in <1 ps.

References:

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