Dynamical magnetoelectric effects associated with ferroelectric domain walls

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It was recently found [1] that a magnetization naturally exists in systems possessing a finite time-derivative of the electric toroidal moment. Interestingly, the ferroelectric domain walls (FDW) separating the nanoscale domains recently observed in ferroelectric ultrathin films [2] can exhibit a non-zero electric toroidal moment. It is thus legitimate to wonder if the *motion* of such FDW can affect their electric toroidal moment and therefore lead to the creation of a magnetization – which would constitute a novel dynamical magnetoelectric effect (ME).

In order to resolve such issue, Molecular dynamics simulations [3] using a first-principles-derived effective Hamiltonian [4] are conducted for lead zirconium titanate (PZT) ultrathin films possessing nanoscale ferroelectric domains and being under GHz electric field. As shown in Fig. 1, pulses of magnetization are indeed predicted in this system, when sudden changes of morphology of these nanodomains occur.

A simple equation relating the magnetization and product between the electrical polarization and its time derivative is further derived from a simple model (via the relation between the magnetization and time derivative of the electrical toroidal moment). This equation explains our numerical findings, as well as ME effects that have been observed 30 years ago in moving ferroelectric domain walls/phase boundaries in ferroelectric $BaTiO_3$ and $Gd_2(MoO_4)_3$ thin films [5-7].

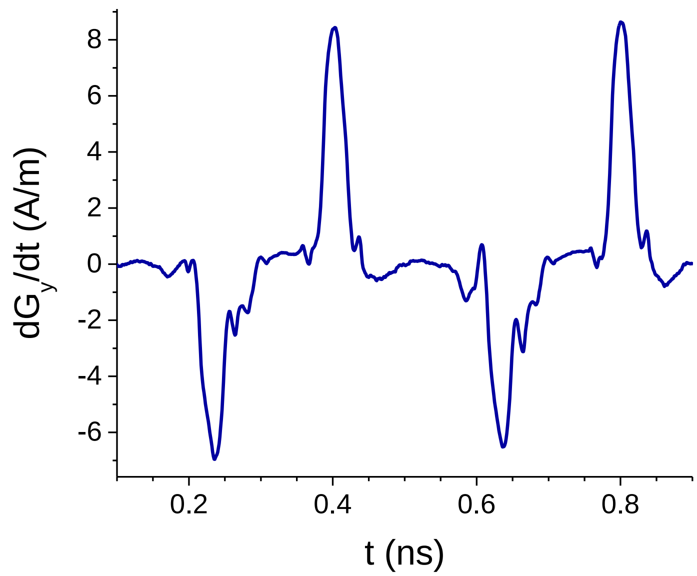

Figure 1. Predicted Time-dependency of the time derivative of the electric toroidal moment in the studied PZT film being under a GHZ electric field.

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