Supplemental Material: Domain wall dynamics in magnetoelastic nanostripes

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ADDITIONAL DETAILS ON THE SYSTEM DESCRIPTION

We add some details concerning the proposed system. We take into consideration the magnetoelastic layer placed on the piezoelectric substrate, as represented in Fig.1a (main text). The stripe shows a uniaxial anisotropy, which tends to align the magnetization along the x-axis (without any preference between positive and negative directions). We propose to apply a magnetic field along the y-axis. From the technological point of view, the system can be simply placed in the air gap of a surrounding magnetic circuit, which includes an arrangement of permanent magnets. Given the lengthscales involved it is rather certain that the homogeneity of the magnetic field generated by such a device would be secured over the whole nanostripe. Anyway, the competition between the magnetic anisotropy and the applied magnetic field generates two energetically equivalent stable orientations for the nanostripe magnetization. We can therefore consider a domain wall between two domains characterized by these two magnetization states, as shown by the arrows distribution within the nanostripe in Fig.1a (main text). To induce the domain wall motion, we take advantage of the magnetostriction of the nanostripe, coupled with the piezoelectric substrate. Indeed, in an arbitrarily strained magnetostrictive layer (with positive magnetostriction), the magnetization tends to be aligned with the direction of the larger geometrical elongation. We can exploit this property through a varying (positive or negative) electric field applied to the piezoelectric substrate, which generates tensile and compressive stress components, as shown in Fig.1b (main text). Consequently, it is not difficult to recognize that a positive electric field leads to a leftward motion of the domain wall, whereas a negative electric field leads to its rightward motion. This is the principle of operation of the proposed system, and it can be exploited with different profiles of the ferromagnetic nanostripe for obtaining specific dynamic behaviors.

MICROMAGNETIC SIMULATIONS

Of course, the analysis of the system proposed in the present paper could be performed with standard micromagnetic simulations. However, the numerical solution of our equations is less costly from the computational point of view and the discussed model provides a deeper understanding of the underlying physics. In order to validate the approximation adopted in our model, namely the consideration of the magnetization as a function of x and t only, we compared the solutions obtained with Eqs.2, 3 and 4 (of the main text) with micromagnetic simulations performed with the Nmag package [1]. In the cases compared, good agreement has been found, with the relative error being smaller than 10%.

DOMAIN WALL SHAPE

We describe here the peculiar form of the domain wall shape, characteristic of the magnetoelastic nanostripe and very different from the well-known Néel or Bloch walls. The behavior of the out-of-plane excursion for the motion within the constant section nanostripe can be observed in Figs.1 and 2. In Fig.1 we show the shape of the domain wall for two opposite values of the electric field. When we apply a positive field, the compressive in-plane strain is larger than the tensile strain and this configuration creates a planar magnetoelastic anisotropy in a ferromagnetic film with positive magnetoelastic coefficient [2]. Such anisotropy favors a large perpendicular-to-plane orientation of the magnetization. On the contrary, a negative electric field induces a tensile strain larger than the compressive strain, creating an in-plane easy axis of magnetization, corresponding to smaller out-of-plane excursions. This explains the asymmetry of the DW dynamics with positive and negative electric field. Besides, the out-of-plane excursions are more pronounced for large values of $|E_0|$, as shown in Fig.2 where the DW shape is represented for two different values of the electric field. The width of the domain wall is also strongly affected by the intensity of the electric field.

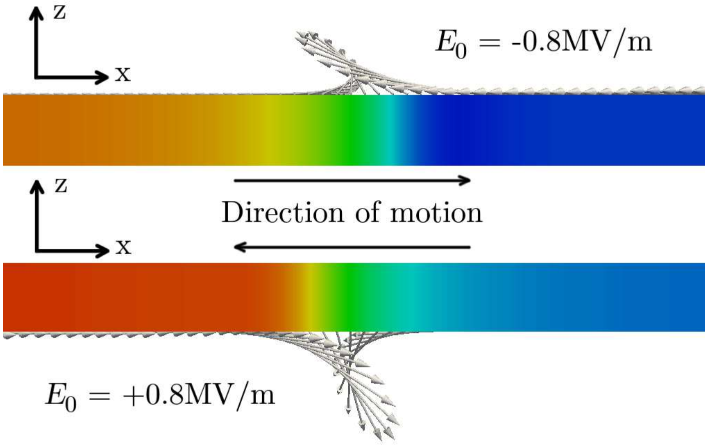

FIG. 1: Representations of the domain wall configuration in motion within the nanostripe with constant section. We show two different cases driven by negative and positive electric fields, corresponding to axial and planar effective magnetic anisotropy, respectively. We observe that the out-of-plane behavior is more pronounced for positive electric fields (planar anisotropy).

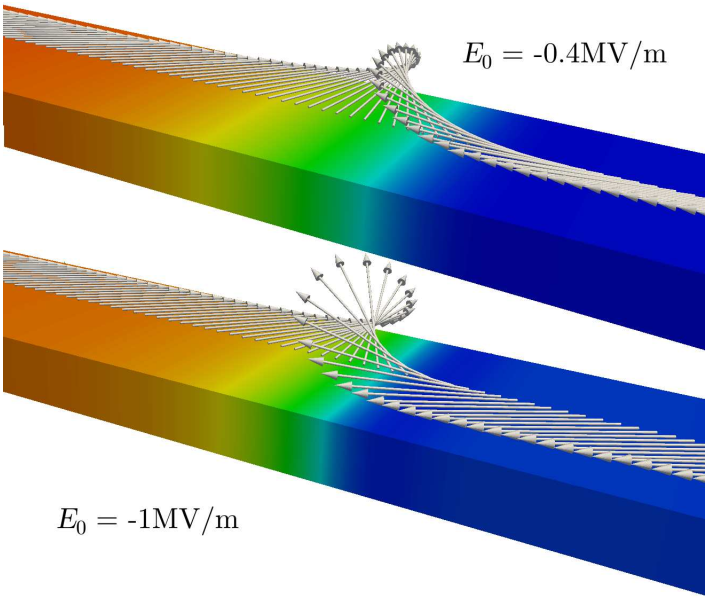

FIG. 2: Perspective representations of the domain wall configuration in motion within the nanostripe with constant section. We show two different cases driven by two different electric fields. We observe that the out-of-plane behavior is more pronounced for higher electric fields.

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[2] N. A. Pertsev, Phys. Rev. B **78**, 212102 (2008).