T06

Magnetic Domain Wall Motion by Propagating Spin Waves

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1. Introduction

Electric-current driven manipulation of domain wall (DW) motions in patterned magnetic thin-film nanowires via the spin transfer torque (STT) of the spin-polarized currents are of growing interest in the research areas of nanomagnetism and spintronics devices[1], due to the potential applications for solid-state data-storage[2] and data-processing devices[3]. Recently, fundamental understandings of the nontrivial dynamic behaviors of DW motions driven by applied magnetic fields and/or spin-polarized currents have been advanced from numerous experimental[4], numerical simulations[5], and theoretical[6] studies. Meanwhile, only a few studies[7,8] on the influence of DWs on spin waves (SWs) propagating through it have been reported from the aspect of manipulation of SWs by the static structures of DWs. In this presentation, we report on the results of a study on transverse wall (TW)-type DW motions driven by propagating SWs through their interaction. We also propose that traveling SWs are an alternative means for the manipulation of DW motions in narrow nanostripes.

2. Simulations

In this study, we chose an approach of micromagnetic numerical calculations[9] on a model system of a Permalloy (Py) nanostripe of t=10nm thickness, l=3005 nm length, and w=50 nm width, wherea head-to-head TW-type DW was placed at the center position(x=0).We perturbed locally the magnetization at either stripe ends using a single harmonic sinusoidal fields for the generation and the injection of SWs having specific frequencies, f_{sw}.

3. Results and Discussion

Fig. 1(a) shows an example of the motion of a TW driven by propagating SWs having f_{sw}= 18 GHz, whereas Fig. 1(b) reveals no motion of the TW for a frequency of f_{sw}=13 GHz. These results evidently show that the TW motions can be controlled by an interaction between the TW and the propagating SWs of specific frequencies. In order to obtain more information on the relationship between f_{sw} and the velocity of TW motions, we also examined the variation of the TW velocity with f_{sw} ranging from 0 to 45GHz. We found that the specific frequencies of SWs, namely, f_{sw}=14.5, 18, 24, 27, and 32 GHz, can drive effectively TW motions with the corresponding velocities, 1.1, 5.9, 4.6, 2.1, and 0.8 m/s, respectively. Moreover, the TW velocity varies with the frequency and the amplitude of propagating SWs. These characteristic frequencies of SWs for driving the TW motions can be understood by the resonant excitation of several local modes associated with the TW structure inside this type of DW through the interaction of the SWs of f_{sw} being tuned to those of the local modes of the TW. The local modes within the TW and the frequency peaks in the average velocity-versus-f_{sw} curve are inquantitative in agreements.

4. Conclusion

TW motions can be resonantly excited by the interaction of SWs with the internal modes of the TW. The TW velocity varies with the frequency and amplitude of the propagating SWs. The results provide an alternative means for controlling DW motion in nanostripes. This work was supported by Creative Research Initiatives (Research Center for Spin Dynamics & Spin-Wave Devices) of MEST/KOSEF and the DFG within the Priority Programme 1133 “Ultrafast magnetization processes”.

5. Reference

[1] M. Hayashi et al., Phys. Rev. Lett. **96**, 197207 (2006).

[2] S.S.P. Parkin et al., Science **320**, 190 (2008).

[3] D.A. Allwood et al., Science **309**, 1688 (2005).

[4] M. Klaui et al., Phys. Rev. Lett. **95**, 026601 (2005);Y.Nakatani et al., Nature materials 2, 521 (2003).

[5] S.-K. Kim et al., Appl. Phys. Lett. **93**, 052503 (2008); J.-Y. Lee et al., Phys. Rev. B 76, 184408 (2007).

[6] K.Y. Guslienko et al., IEEE Trans. Mag. **44**, 3079 (2008).

[7] C.W. Sandweg et al., J. Phys. D-Appl. Phys. **41**,164017 (2008).

[8] R. Hertel et al.,Phys. Rev. Lett. **93**, 257202 (2004).

[9] See http://math.nist.gov/oommf.

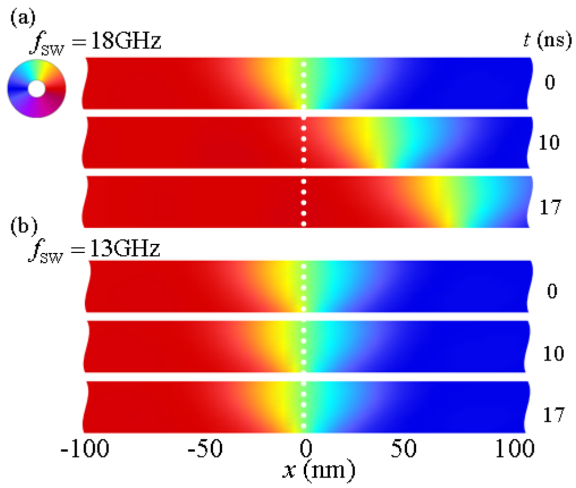

Fig. 1. Top-view snapshot images of the spatial distribution of the in-plane orientations of local Ms, displaying the temporal evolution of the motion of the TW, driven by propagating SWs of fSW=18 and 13 GHz in a and b, respectively. The vertical white-dotted line denotes the center position, x=0.