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Self-consistent calculations of transport and magnetization dynamics

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In layered structures like spin-valves where the current flows perpendicular to the plane, the direction and magnitude of the spin transfer torque (STT) at a point r is decided by the spin accumulation (SA) and associated spin current at the same point r. Initial STT theories commonly assumed that the dependence of SA on magnetization (M) is local and thus essentially fixed by the local M at the same point r. However, its dependence on M is inherently nonlocal because of the 3-dimensional spin diffusion [1]. In other words, when the conduction electron arrives at a point r on the ferromagnet-normal metal interface, the reflected (transmitted) electron takes the spin direction anti-parallel (parallel) to the local M at the point r, diffuses along the interface, and then transfers its spin-angular momentum to another local M at a far away point from the r. That is, SA at a point r is affected by all local M's at other points. The local assumption becomes really invalid when M is inhomogeneous. Note that micromagnetic and time-resolved imaging studies [2] have revealed excitations of incoherent spin-waves and thus inhomogeneous M due to STT. In this situation, the effect of SA on M (=STT) and the nonlocal effect of M on the SA should be treated on an equal footing. The conventional treatments, which ignore the latter part, actually deal with only half of the relevant parts. Therefore, the self-consistent feedback between inhomogenous M and STT through the nonlocal effect should be considered. In this talk, we present self-consistent calculation results that consider the feedback, which allows us to understand peculiar spin-wave modes in a single ferromagnet and a spin-valve. If time is allowed, we extend our talk to other feedback mechanisms which result in the oscillatory STT due to ballistic spin transport [3] and the damping tensor due to the spin-motive force [4] in a very narrow magnetic domain wall. These works have been done in collaboration with Hyun-Woo Lee at POSTECH, Jung-Hwan Moon and Sang-Il Kim at Korea University.

[1] M. L. Polianski and P. W. Brouwer, Phys. Rev. Lett. 92, 026602 (2004); M. D. Stiles, J. Xiao and A. Zhangwill, Phys. Rev. B 69, 054408 (2004); A. Brataas, Y. Tserkovnyak and G. E. W. Bauer, Phys. Rev. B 73, 014408 (2006).

[2] K.-J. Lee et al. Nature Mat. 3, 877 (2004); K.-J. Lee and B. Dieny, Appl. Phys. Lett. 88, 132506 (2006); Y. Acremann et al. Phys. Rev. Lett. 96, 217201 (2006).

[3] J. Xiao, A. Zhangwill and M. D. Stiles, Phys. Rev. B 73, 054428 (2006).

[4] S. Zhang and S. S.-L. Zhang, Phys. Rev. Lett. 102, 086601 (2009).