Current-induced dynamics in dielectric antiferromagnets

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Antiferromagnetic (AFM) materials have natural resonance frequencies in the sub-THz to THz frequency range. Thus, it is tempting to use antiferromagnets as active layers in THz-frequency spin-torque nano-oscillators (STNOs). However, a familiar mechanism of spin-transfer torque (STT) damping compensation used in ferromagnetic (FM) STNOs [1] does not work for the AFM materials. In the AFM two magnetic sublattices are aligned anti-parallel to each other, so, when the STT compensates damping in one of the sublattices, it increases the damping in the other sublattice, resulting in a zero net effect. At the same time, the STT can cause a lattice instability in an AFM. For example, it has been shown in [2], that the STT can lead to the reorientation of the order vector *l* in the AFM with cubic anisotropy.

In this work we propose a novel approach to the excitation of oscillations in AFM materials. In the framework of this approach the STT is used to change the *effective energy landscape* of the AFM. We show theoretically, that in a *bi-axial* AFM (such as NiO [3]) the magnetic lattice can lose its stability under the action of STT, which results in a self-sustained precession of the order vector ***l*** of the AFM. We found that for NiO the lowest threshold of the self-sustained oscillations occurs for the STT directed along the *hard axis* of a single crystal NiO. The threshold of generation in this case is determined by the weak easy plane anisotropy ($H_{a1} \approx$ 380 Oe in NiO) of the bi-axial AFM, and *not* by the Gilbert damping of the AFM. Above the generation threshold the AFM order vector ***l*** starts to precess in the AFM easy plane with the frequency defined by the magnitude of the STT and by the Gilbert damping in the AFM, see Fig. 2. The threshold of the self-sustained oscillations for the case of the STT directed along the easy axis of the AFM in several orders of magnitude higher, than in the case when the STT is directed along the AFM hard axis.

[1] A. Slavin and V. Tiberkevich IEEE Trans. on Magn. 45, 1875 (2009)
[2] E. V. Gomonai and V. M. Loktev Low Temp. Phys. 34, 198 (2008)
[3] A.J. Sievers and M. Tinkham, Phys. Rev. 129, 1566 (1963)