## Generation of THz-frequency oscillations in canted antiferromagnets

A. N. Slavin[1], O. Sulymenko[2] and V. S. Tiberkevich[1]

[1] *Department of Physics, Oakland University, Rochester, Michigan 48309, USA*

[2] *Taras Shevchenko National University of Kyiv, Kyiv 01601, Ukraine*

The antiferromagnets (AFM) are seen as materials for novel THz-frequency signal processing devices [1,2]. In contrast to the devices based on ferromagnets (FM), the AFM-based devices do not require any external bias magnetic field. Also, the ultrafast magnetization dynamics of the AFM devices is determined by the strong internal exchange field that exists in AFM materials, and keeps their magnetic sublattices anti-parallel to each other. This exchange field determines the high natural frequencies of the AFM resonance, lying 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 , where the output electromagnetic signal is received using the inverse spin-Hall effect (ISHE) in the NiO/Pt layered structure [3]. Unfortunately, the amplitude of the generated THz-frequency signal is such an AFM oscillator decreases with the increase of frequency, making the generation process less efficient (see Fig.1).

To meet this challenge, we propose a design of a THz-frequency signal generator based on a the AFM/Pt layered structure where the magnetization vectors of the AFM (e.g. Hematite $Fe_2O_3$) sublattices are *canted inside the easy plane* by the Dzyaloshinskii-Moriya interaction (DMI), resulting in the formation of a small net magnetization $\mathbf{m}_{DMI}$. The perpendicularly polarized spin current, created by a driving DC electric current in the Pt layer, tilts the DMI-canted AFM sublattices out of the easy plane, thus exposing them to the action of a strong internal exchange magnetic field of the AFM. The sublattice magnetizations, along with the small net magnetization vector $\mathbf{m}_{DMI}$ of the canted AFM, start to rotate about the hard anisotropy axis of the AFM with the THz frequency proportional to the injected spin current and the AFM exchange field. The rotation of the small net magnetization $\mathbf{m}_{DMI}$ results in the THz-frequency dipolar radiation that can be directly received by an adjacent (e.g. dielectric) resonator. We demonstrate theoretically that the radiation frequencies in the range f = 0.05 - 2 THz are possible at the experimentally reachable magnitudes of the driving current density, and evaluate the power of the signal radiated into different types of resonators, showing that this power increases with the increase of frequency and could reach several $\mu W$ when a dielectric resonator with a typical quality factor of Q= 750 is used.

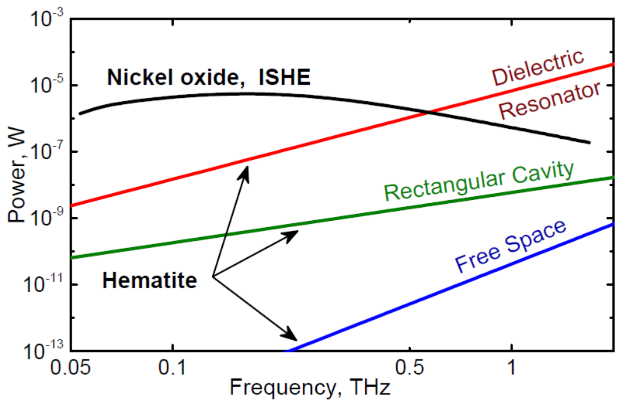


**Figure 1.** Generated power vs. frequency for an oscillator based on amlayer (thickness $d_{AFM}$ = 5 nm) of a canted AFM (Hematite) providing dipolar radiation into different types of resonance systems. For comparison, a similar curve is presented for an oscillator based on un-cunted NiO, where the signal is extracted using ISHE in the adjacent Pt layer

[1] T. Jungwirth et al. , Nature Nanotechnology **11**, 231 (2016).
[2] O. Gomonay et al., Phys. Status Solidi RRL **11**,1700022 (2017)
[3] R. Khymyn et al., Scientific Reports **7**, 43705 (2017).