Spintronic Diode as a Quadratic Signal Detector and RF Energy Harvester

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The spin-torque magnetic diode (STMD) effect [1] is a quadratic rectification effect of the input microwave current $I_{RF}(t)$ in a magneto-resistive nano-junction, which is commonly observed in a traditional regime of operation of an STMD, when the magnetization of the "free" layer lies *in-plane*, and when the frequency f_s of the current $I_{RF}(t)$ is close to the ferromagnetic resonance (FMR) frequency f_0 of the junction. It was demonstrated theoretically in [2] that in an STMD, biased by an *out-of-plane* static magnetic field, a novel dynamical regime of STMD operation characterized by large-angle out-of-plane magnetization precession can be realized.

It was demonstrated experimentally in [3] that the out-of-plane magnetization precession regime in an STMD predicted in [2] can be realized without *any bias magnetic field*, if an STMD "free" layer has a *perpendicular magnetic anisotropy*. It was further shown in [3] that the developed bias-free STMD provides sufficient dc voltage to power a practical nanodevice – a black phosphorus photosensor. Here we present an analytical and numerical theory explaining the performance of such a bias-free STMD with perpendicular magnetic anisotropy [4]. We show that such a device can operate as a broadband energy harvester capable of converting incident RF power into a DC power with a conversion efficiency of ~5%.

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[3] B. Fang, M. Carpentieri, S. Louis et al., Phys. Rev. Appl., Vol. 11, p.014022 (2019).
[4] P. Yu. Artemchuk, O. V. Prokopenko, E. N. Bankowski *et al*., AIP Advances., Vol. 11, p. 025234 (2021).

Andrei Slavin received PhD degree in Physics in 1977 from the St. Petersburg Technical University, St. Petersburg, Russia. Dr. Slavin developed a state-of-the-art theory of spin-torque oscillators, which has numerous applications in the theory of current-driven magnetization dynamics in magnetic nanostructures. His current research support includes multiple grants from the U.S. Army, DARPA, SRC and the National Science Foundation. This research involves international collaborations with leading scientists in many countries, including Germany, Ukraine, France, Italy, and the United States. Dr. Slavin is a frequently invited speaker at magnetism conferences around the world.

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