MAR13-2012-020209

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

GMAG PhD Dissertation Research Award Talk: Experimental characterization of non-isochronous properties of spin torque nano-oscillators

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Spin Torque Oscillators (STO) are nano-sized auto- oscillators whose frequency can be tuned in a wide range. This tuning originates from the nonlinear properties of the underlying magnetization dynamics that is induced by spin transfer torque (STT) in magnetic nanostructures. Being highly tunable in frequency has the inconvenience of being very sensitive to noise. As a result the spectral purity of STOs is below the one required for applications. The magnetization dynamics induced by STT has been described theoretically in the frame of a non-isochronous auto-oscillator model [1]. Within this model the important information on the excitation mode is contained within two phenomenological parameters which are, the amplitude-phase coupling ν, and the amplitude relaxation rate Γ_p. They completely determine the non-autonomous oscillator response and their experimental determination is thus an important issue. This presentation describes several experimental methods to extract these parameters. The first involves time domain noise spectroscopy which permits the power spectral density of phase and amplitude noise to be extracted [2]. The analysis of such noise in light of theoretical models allows not only direct extraction of the nonlinear parameters, but also to quantify the phase noise - the characteristics important for applications. This is demonstrated for magnetic tunnel junction devices. A second method involves the analysis of higher harmonic linewidths Δf_n [3], where it is shown that due to the non-isochronous property of STOs, the relationship between Δf_n and Δf_1 is nontrivial and allows one to extract ν and Γ_p. We then apply the information gathered on the autonomous dynamics of STOs to understand their non-autonomous dynamics that are a prerequisite for the use of STOs in more complex devices (field sensors, frequency synthesizers, etc). It is shown experimentally how the nonlinear parameters ν and Γ_p determine this non-autonomous behavior of the STO.

[1] A. Slavinand and V. Tiberkevich, IEEE Trans on Mag 45, 1875 (2009)
[2] M. Quinsat et al. APL 97, 182507 (2010)
[3] M. Quinsat et al. PRB 86, 104418 (2012)