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Decoherence and mode-hopping in spin-torque oscillators

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A Spin Torque Oscillator (STO) is a nano-sized magneto-resistive device that can produce microwave signals in the GHz range as a result of spin transfer torque [1, 2]- a phenomena which is receiving increasing importance in contemporary spintronics research both for fundamental spin physics as well as a number of possible microwave applications e.g., oscillator, detectors and modulators. A very important question, both for fundamental physics as well for applications, is what limits the coherence time of the STO. This is a subject of significant interest recently. Until now theoretical studies have investigated decoherence through thermal noise assuming that only a single mode is excited [3]. On the other hand, experiments clearly show both the existence of multiple modes and persistent mode-hopping between several modes. The impact on coherence time of such mode-hopping has been largely unexplored and a theoretical study of its origin is entirely lacking. In this work, we will present first ever systematic experimental investigations of mode hopping, and its impact on the coherence time in a magnetic tunnel junction based spin torque oscillator [4]. We will discuss micromagnetic simulations and a theoretical treatment to show that the non-conservative fields due to finite damping-either positive or negative (spin torque) -couple individual modes and, in the presence of thermal noise, govern the experimentally observed mode-hopping. Using quantitative analysis of both coherence and dwell times, we will show that mode-hopping could be a limiting factor for STO coherence. Finally we show how our theoretical treatment can be extended to the case of a metallic nanocontact based STO, where anomalous temperature dependence of linewidth is found as result of the mode coupling [5].

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