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Autonomous and driven dynamics of spin torque nano-oscillators[1]

SERGEI URAZHDIN, Emory University

Understanding the dynamical properties of autonomous spin torque nano-oscillators (STNO) and their response to external perturbations is important for their applications as nanoscale microwave sources. We used spectroscopic measurements to study the dynamical characteristics of nanopillar- and point contact-based STNOs incorporating a microstrip in close proximity to the active magnetic layer. By applying microwave current at frequency f_{ext} to the microstrip, we were able to generate large microwave fields of more than 30 Oe rms at the location of STNO. We demonstrate that for a wide range of f_{ext}, STNO exhibits multiple synchronization regimes with integer and non-integer rational ratios between f_{ext} and the oscillation frequency f. We show that the synchronization ranges are determined by the symmetry of the oscillation orbit and the orientation of the driving field relative to the symmetry axis of the orbit. We observe synchronization hysteresis, i.e. a dependence of the synchronization limits on the dynamical history caused by the nonlinearity of STNO. We also show that the oscillation can be parametrically excited in the subcritical regime of STNO by a microwave field at twice the frequency of the oscillation. By measuring the threshold and the frequency range of parametric excitation, we determine damping, spin-polarization efficiency, and coupling to the microwave signal. In addition, by measuring the frequency range of parametric synchronization in the auto-oscillation regime, we determine the dynamic nonlinearity of the nanomagnet. Thus, analysis of the driven oscillations provides complete information about the dynamical characteristics of STNO. Finally, we discuss several unusual dynamical behaviors of STNO caused by their strong nonlinearity.

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