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The magnetization dynamics of nano-contact spin-torque vortex oscillators[1]

PAUL KEATLEY, University of Exeter

The operation of nano-contact (NC) spin-torque vortex oscillators (STVOs) is underpinned by vortex gyration in response to spin-torque delivered by high density current passing through the magnetic layers of a spin valve. Gyration directly beneath the NC yields radio frequency (RF) emission through the giant magnetoresistance (GMR) effect, which can be readily detected electronically. The magnetization dynamics that extend beyond the NC perimeter contribute little to the GMR signal, but are crucial for synchronization of multiple NC-STVOs that share the same spin valve film. In this work time-resolved scanning Kerr microscopy (TRSKM) was used to directly image the extended dynamics of STVOs phase-locked to an injected RF current. In this talk the dynamics of single 250-nm diameter NCs, and a pair of 100-nm diameter NCs, will be presented. In general the Kerr images reveal well-defined localized and far-field dynamics, driven by spin-torque and RF current Oersted fields respectively. The RF frequency, RF Oersted field, direction of an in-plane magnetic field, and equilibrium magnetic state, all influenced the spatial character of the dynamics observed in single NCs. In the pair of NCs, two modes were observed in the RF emission. Kerr images revealed that a vortex was formed beneath each NC and that the mode with enhanced spectral amplitude and line quality appeared to be correlated with two localized regions oscillating with similar amplitude and phase, while a second weaker mode exhibited amplitude and phase differences. This suggests that the RF emission was generated by collective modes of vortex gyration dynamically coupled via magnetization dynamics and dipolar interactions of the shared magnetic layers. Within the constraints of injection locking, this work demonstrates that TRSKM can provide valuable insight into the spatial character and time-evolution of magnetization dynamics generated by NC-STVOs and the conditions that may favor their synchronization.

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