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Magnetic droplets in nano-contact spin-torque oscillators with perpendicular magnetic anisotropy[1]

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The theoretical prediction, by Ivanov and Kosevich [1], of "magnon drop" solitons in thin films with perpendicular magnetic anisotropy (PMA) and zero damping, dates back to the 1970s. More recently, Hoefer, Silva and Keller [2], demonstrated analytically and numerically that related "magnetic droplet" solitons should be possible to excite in nano-contact spin-torque oscillators (NC-STOs) based on PMA materials, where spin transfer torque locally realizes the zero-damping condition required in [1]. In my talk, I will present the first experimental demonstration of such magnetic droplets, realized using 50-100 nm diameter nano-contacts (NCs) fabricated on top of orthogonal GMR stacks of Co8/Cu/Co0.3[Ni0.8/Co0.4]x4 (thicknesses in nm). The nucleation of a magnetic droplet manifests itself as a dramatic 10 GHz drop in microwave signal frequency at a drive-current dependent critical perpendicular field of the order of 0.5 - 1 T. The drop in frequency is accompanied by a simultaneous sharp resistance increase of the device and a sign change of its magnetoresistance, directly indicating the existence of a reversed magnetization in a region of the [Co/Ni] free layer underneath the NC. As predicted by numerical simulations the droplet exhibits rich magnetodynamic properties, experimentally observed as auto-modulation at approximately 1 GHz and sometimes sidebands at 1/2 and 3/2 of the fundamental droplet frequency. The 1 GHz modulation can be shown numerically to be related to the drift instability of the droplet [2], albeit with enough restoring force to make the droplet perform a periodic motion instead of leaving the NC region. The sidebands at 1/2 and 3/2 the droplet frequency are related to eigenmodes of the droplet perimeter. Magnetic droplet nucleation is found to be robust and reproducible over a wide number of NC-STOs with different NC sizes, making this new nanomagnetic object as fundamental and potentially useful to nanomagnetism as e.g. domain walls and vortices.

[1] B. A. Ivanov and A. M. Koseich, Zh. Eksp. Teor. Fiz. 72, 2000 (1977)
[2] M. A. Hoefer, T. J. Silva, and M. W. Keller, Phys. Rev. B 82, 054432 (2010)

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