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Magnetic droplets and dynamical skyrmions

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Nanocontact spin-torque oscillators (NC-STOs) provide an excellent environment for studying nano-magnetic phenomena such as localized and propagating auto-oscillatory spin wave (SW) modes. The recent experimental observation of magnetic droplet solitons in NC-STOs with perpendicular magnetic anisotropy (PMA) free layers [1], and the numerical [2] and experimental [3] demonstrations of spin transfer torque (STT) nucleated skyrmions in similar magnetic thin films add two interesting and useful nanoscale magnetic objects. Due to the competition between exchange, anisotropy, and, in the case of skyrmions, the Dzyaloshinskii-Moriya interaction (DMI), the droplet and the skyrmion are extremely compact, on the order of 10-100 nm. One of the main differences between a magnetic dissipative droplet soliton and a skyrmion is that the former is a dynamical object with all its spins precessing around an effective field and stabilized by STT, exchange, and PMA, while the latter has static spins and an internal structure stabilized by DMI, exchange, and PMA. The dissipative droplet is furthermore a non-topological soliton, while the skyrmion is topologically protected. In this work I will report on our most recent droplet experiments, including droplet collapse at very high fields, droplets excited in nano-wire based NC-STOs, and studies of the field-current droplet nucleation boundary. I will also demonstrate numerically and analytically that STT driven precession can stabilize so-called dynamical skyrmions even in the absence of DMI, and I will describe their very promising properties in detail. From a more fundamental perspective, precession is hence a third independent possibility to stabilize a skyrmion, without the need for the conventional stabilization from either dipolar energy or DMI.

[1] S. M. Mohseni et al, Science 339, 1295 (2013).
[2] J. Sampaio et al, Nature Nanotechn. 8, 839 (2013).
[3] N. Romming et al, Science 341, 636 (2013)