MAR17-2016-020592

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Magnon Condensates in Spin-Transfer Torque Nanocontacts[1]

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In ferromagnets with uniaxial magnetic anisotropy there is an attractive interaction between spin-wave excitations or magnons. This can lead to the formation of a magnon condensate, predicted in the late 1970s—also known as a magnetic droplet soliton [1]. Only recently has it been possible to realize this state experimentally by creating a non-equilibrium magnon population using spin-transfer torques from a spin-polarized current. Experiments are conducted using a nanocontact to a thin film with perpendicular magnetic anisotropy [3-6]. DC and high frequency transport measurements demonstrate that magnetic droplet solitons exhibit a strong hysteretic response to field and current, showing the existence of bistable states: droplet and non-droplet states [4]. We also present the first direct observation of droplet solitons using scanning transmission x-ray microscopy (SXTM) [5]. Element resolved x-ray magnetic circular dichroism images show an abrupt onset of magnetic solitons at a threshold current, as predicted by theory [2]. The amplitude of the excitation, however, is far less than predicted. A possible origin of this discrepancy is a resonant drift instability, whereby the droplet periodically moves out of the contact region, annihilates and renucleates in the nanocontact [6,7]. Our recent measurements of the time scale for droplet generation and annihilation with pulsed currents show that annihilation takes several ns but the generation time is much longer, $\sim$ 100 ns. These recent results will be presented along with a prespective on future experiments with magnon condensates.

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[1]In collaboration with F. Macia, D. Backes, S. Bonetti, R. Kukreja, H. Ohldag, S. Lendinez, N. Statuto, J. Hang and C. Hahn. Supported in part by NSF-DMR-1309202 & 1610416.