MAR14-2013-020543

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Onset of a Propagating Self-Sustained Spin Reversal Front in a Magnetic System[1]

ANDREW D. KENT, Department of Physics, New York University

The energy released in a magnetic material by reversing spins as they relax toward equilibrium can lead to a dynamical magnetic instability in which all the spins in a sample rapidly reverse in a run-away process known as magnetic deflagration. A well-defined front separating reversed and un-reversed spins develops that propagates at a constant speed. This process is akin to a chemical reaction in which a flammable substance ignites and the resulting exothermic reaction leads via thermal conduction to increases in the temperature of an adjacent unburned substance that ignites it. In a magnetic system the reaction is the reversal of spins that releases Zeeman energy and the magnetic anisotropy barrier is the reaction's activation energy. An interesting aspect of magnetic systems is that these key energies–the activation energy and the energy released– can be independently controlled by applied magnetic fields enabling systematic studies of these magnetic instabilities. We have studied the instability that leads to the ignition of magnetic deflagration in a thermally driven Mn_{12}-Ac molecular magnet single crystal. Each Mn_{12}-ac molecule is a uniaxial nanomagnet with spin 10 and energy barrier of 60 K. We use a longitudinal field (a field parallel to the easy axis) to set the energy released and a transverse field to control the activation energy. A heat pulse is applied to one end of the crystal to initiate the process. We study the crossover between slow magnetic relaxation and rapid, self-sustained magnetic deflagration as a function of these fields at low temperature (0.5 K). An array of Hall sensors adjacent to a single crystal is used to detect and measure the speed of the spin-reversal front. I will describe a simple model we developed based on a reaction-diffusion process that describes our experimental findings. I will also discuss prospects for observing spin-fronts driven by magnetic dipole interactions between molecules that can be sonic, i.e. travel near the speed of sound ($\sim$ 1000 m/s).

P. Subedi, S. Velez, F. Macia, S. Li, M. P. Sarachik, J. Tejada, S. Mukherjee, G. Christou and A. D. Kent, Physical Review Letters **110**, 207203 (2013)

[1]In collaboration with P. Subedi, S. Velez, F. Macià, S. Li, M. P. Sarachik, J. Tejada, S. Mukherjee and G. Christou. Supported by NSF-DMR-1006575.