Opportunities in Nanomagnetism*

Borrowed from Sam Bader
Argonne National Labs

Grand Challenges in Nanomagnetism

- Ultra Strong Permanent Magnets
- Ultra High Density Media
- Spin Transistor With Gain
- ~100% Spin Polarized Materials
- R.T. Magnetic Semiconductors
- Instant Boot-Up Computer
- Magnetic Logic
- Spin-Based Qubits
- Hierarchically Assembled Media
- Computer From Test Tube
- Nano-Bio Mag Sensors
Magnetic Random Access Memory

Now in production by Freescale Semiconductor (Motorola)

http://www.freescale.com/
Grand Challenges in Nanomagnetism

Ultra Strong Permanent Magnets

Ultra High Density Media

Spin Transistor With Gain

~100% Spin Polarized Materials

R.T. Magnetic Semiconductors

Instant Boot-Up Computer

Magnetic Logic

Spin-Based Qubits

Hierarchically Assembled Media

Computer From Test Tube

Nano-Bio Mag Sensors
Magnetization reversal due to formation of the magnetic vortex state in circular dot

Magnetic Vortex State in Disk-shaped Nanomagnets
Submicron Permalloy Stadia


Simulation key

D = 400 nm

- Structures
- Nucleation
- Interactions
Virtual Particles

D = 400 nm
L = 300 nm

D = 400 nm
L = 500 nm
Core Interactions

Magnetic Field \( \hat{x} \) (Oe)

- Vortex / Antivortex same core magnetization
- Vortex / Antivortex opposite core magnetization

Distance from end of Stadium (% total length)

Annihilation
In the reversal process, past a critical aspect ratio, vortex-antivortex pair creation facilitates the reversal.

Understanding the vortex-antivortex nucleation and annihilation is not as simple as we thought as the associated energies do not vary much so it is all hidden in the dynamics.

**Cuteness factor** - like field theory in stop action animation - for Casimir effect, black hole decay, and Kosterlitz-Thouless transition.