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Vortices in Ferroelectric Nanostructures

Low-dimensional ferroelectrics are of increasing interest, mainly due to their potential applications in the next-generation high-density memories. They are also attractive from a fundamental point due to their capability to exhibit unique properties, such as the formation of 180^0 *stripe domains* in ultra-thin films. As all three dimensions of the ferroelectric system shrink to the nanoscale, it becomes progressively *more difficult* for the system to minimize its depolarizing fields via splitting into domains. Rather, as we predicted in 2004, the system will form flux closing dipole configurations or *vortices* that can be appropriately described by a topological order parameter, the *toroid moment* **G** [1]. Since that prediction, the "toroidal ferroelectricity" has evolved into a hot spot in the area of ferroic research. The aim of this talk is to discuss some recent and ongoing theoretical and some experimental studies revealing original properties of vortices in ferroelectric nanostructures. In particular, I will emphasize the following items:

Toroidal moment as an order parameter; and corresponding susceptibilities.
Vortices from first-principles DFT calculations.
Mounting experimental evidence for the existence of the vortex polarization.
Vortex closure domains vs stripe domains.
Ferroelectric vortices vs magnetic counterparts.
The possible control of vortex states by electric and magnetic fields; vortex switching.
First-principles design of materials that can easily adopt the vortex states.

[1] Ivan I. Naumov, L. Bellaiche and Huaxiang Fu, Nature (London) **432,** 737 (2004).

Friday, May 20, 2011
237 Scott Engineering Center, 1:30 p.m.
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