# Control of vortices by homogeneous fields in asymmetric ferroelectric and ferromagnetic rings

S. Prosandeev[1], I. Ponomareva[1], I. Kornev[2], and L. Bellaiche[1]

[1] *Physics Department, University of Arkansas, Fayetteville, Arkansas 72701, USA*

[2] *Mads Clausen Institute for Product Innovation University of Southern Denmark, Alsion 2, DK-6400 Sonderborg*

Vortex states, in which the dipoles form a closure structure, have been discovered in small magnetic disks and predicted in ferroelectric nanodots. The existence of these states hold a tremendous potential for nanotechnological applications. However, a successful realization of this potential crucially depends on the ability to control the chirality of the vortex states. An exceptional promise is nowadays associated with asymmetric ferromagnetic rings, whose vortices have been shown to be controllable via the application of a homogeneous magnetic field (see Ref. [1] and references therein). However, the underlying mechanism behind such switching remains a mystery, since magnetic vortices are not supposed to directly couple with an homogeneous magnetic field. Another important unanswered question is to know if the interaction between a vortex state in an asymmetric ring and an homogeneous field is unique to ferromagnets or rather if other dipolar systems (such as ferroelectrics, for instance) have similar interactions. To answer these questions, we develop computational techniques to investigate vortex switching in ferromagnetic and ferroelectric asymmetric rings. Results of our simulations revealed that it is indeed possible to control vortex states in both ferromagnetic and ferroelecric asymmetric rings by means of homogeneous magnetic and electric fields, respectively. However, the mechanisms behind such interactions and the intermediate states involved in the switching are very different for these two kinds of systems. For example, the switching in ferromagnetic rings involves the formation of onion states whereas in ferroelectric nanorings no such state occurs (likely due to the dominant contribution of the depolarizing field). The intermediate states in the asymmetric ferroelectric nanorings are rather characterized by the formation and subsequent growth of a second vortex having a chirality opposite to the main one. The hysteresis loops for ferromagnetic and ferroelectric asymmetric rings we are also found to be qualitatively different. We also explain why vortex controls are possible in these systems by proving that the magnetic (respectively, electric) vortex directly interacts with a previously overlooked physical object, namely with the cross product of a vector characterizing the system's asymmetry and the homogeneous magnetic (respectively, electric) field [2].

[1] C. L. Chien, F. Q. Zhu, and J-G Zhu, *Physics Today*, **92**, 40 (2007).

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