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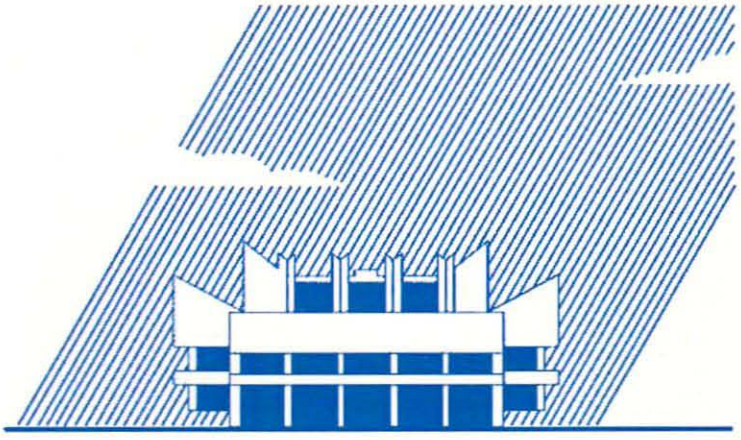

MAGNETIC VORTICES IN NANOPARTICLES

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The active control of nonlinear dynamical systems is a fastly developing area of condensed matter physics. Artificial nanomagnetic systems (magnetic nanoparticles and their superstructures) have acquired a significant place in physics as well as in technology. Essentially inhomogeneous states can be realized in magnetic nanoparticles. Due to nontrivial topological properties and nonlinear interactions, a problem of dynamics of inhomogeneous states in nanomagnets is a problem of non one dimensional topological solitons. Recent direct experimental observations of vortices in such systems argue that vortices can form a ground state in such nanoelements with sizes larger than some tens of nanometers: e. g. for the Permalloy (Py, $Ni_{20}Fe_{80}$) nanodot the critical size is about 50 nm. Namely magnetic vortices provide stable bit at the scale of about 100 nm. Magnetic nanoparticles at vortex state and their structures are very promising candidates for the high density magnetic storage and high speed speed nonvolatile magnetic random access memory (MRAM) and spin-torque random access memory (STRAM). One bit of information can be associated with vortex polarity, i.e. the upward or downward magnetization direction in centre of the vortex core. To this effect one needs to control the switching process of the vortex polarity.

A short overview of statics and dynamics of magnetic vortices in nanomagnets will be presented. In particular, we discuss the vortex structure in nanodots of different geometries and curvatures. We consider magnetization dynamics in nanodots: linear problem of vortex-magnon interaction and nonlinear vortex dynamics.

The special interest is a controlled vortex dynamics under the influence of magnetic fields and spin-polarized currents. Exciting the vortex motion by high-frequency magnetic fields or by a spin polarized currents, one can switch the vortex polarity on a picoseconds time scale. The ultrafast switching of the vortex core magnetization opens doors to consider the vortex state nanoparticles as promising candidates for magnetic elements of storage devices. There are different scenarios of the switching process: (i) The symmetric or so-called punch-through core reversal takes place under the action of a dc magnetic field applied perpendicularly to the magnet plane. This reversal process, as a rule, is mediated by the creation of Bloch points. (ii) The switching, under the action of different in-plane ac magnetic fields or by spin-polarized currents, is accompanied by the temporary creation and annihilation of the vortex-antivortex pair. The latter is accompanied by Bloch point creation.

We discuss the switching phenomena in vortex dynamics and the spatially periodic vortex-antivortex structures which appear in nanomagnets under influence of spin-transfer torque.