B. Verkin Institute for Low Temperature Physics and Engineering
The National Academy of Science of Ukraine

Council of Young Scientists of
B.Verkin Institute for Low Temperature Physics and Engeneering

ICYS * LTP 2012

International Conference for Young Scientists

LOW TEMPERATURE PHYSICS

Conference programme and Abstract book

14-18 May 2012 Kharkiv

ORIGIN OF SPIN-CURRENT INDUCED REGULAR VORTEX-ANTIVORTEX STRUCTURES IN NANOMAGNETS

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Magnetic vortex is a common ground state of submicron sized ferromagnetic particles of high symmetry shape. The vortex has closed magnetic flux within the sample plane and it has vertical out-of-plain component of magnetization vector in the center of structure. Such particles can be used for creation of fast and high density magnetic storage devices. One way to control the behavior of magnetic vortices is to pass a spin-polarized current through the nanodot. It was shown theoretically [1] and experimentally [2] that dc spin-polarized current passing perpendicular to the nanodisk can excite the circular motion of the vortex core. Such motion can be excited [1] under the two conditions: the current density exceeds some critical value j_C and $jp\sigma < 0$, where $\sigma = \pm 1$ is direction of spin polarization of the current (along the normal to the nanodisk), and $p = \pm 1$ is the vortex polarity (the direction of the vortex core magnetization). When $jp\sigma > 0$, the vortex core remain at the center of the disk.

In our research we show that passing the spin-polarized current with $jp\sigma > 0$ through magnetic nanodot can lead to creation of *periodic vortex-antivortex arrays* [3]. One can distinguish two critical current densities during the lattice formation process: When $j < j_1$ the stationary state of the system is a deformed vortex state with negligibly small changes of the out-of-plane magnetization and appreciably deformed in-plane one. When $j > j_2$ the system goes in a saturation state with all spins aligned along z-axis. When $j_1 < j < j_2$ a rich variety of dynamic states is observed: the system demonstrates either chaotic dynamics of vortex-antivortex 2D gas or regular stable vortex-antivortex structures. Near the critical current j_2 the only square vortex-antivortex lattices appear in the system. The origin of such lattice formation is a loss of stability of the current saturated state $m_z = 1$ when the current decreases. Using the Fourier technique we develop the linear theory of instability of the saturated state $m_z = 1$ and find the instability region, i.e. the region of superlattice existence:

$$j(q) < \sqrt{\left(1 - l^2 q^2\right)\left(l^2 q^2 - 1 + \frac{qh - 1 + e^{-qh}}{qh}\right)},$$

where q is absolute value of the wave vector, h is sample thickness, l is exchange length and j i normalized current density. This dependence is well pronounced by simulations [4].

This work was supported by the Grant of the President of Ukraine № F35/538-2011

[1] D. D. Sheka, Y. Gaididei, and F. G. Mertens, Appl. Phys. Lett. **91**, 082509 (2007); Y. Gaidide V. P. Kravchuk, and D. D. Sheka, International Journal of Quantum Chemistry 110, **83** (2010)
[2] V. S. Pribiag, I. N. Krivorotov, G. D. Fuchs, P. M. Braganca, O. Ozatay, J. C. Sanckey, D. C Ralph, and R. A. Buhrman, Nat. Phys. **3**, 498 (Jul. 2007)
[3] O.M. Volkov, V.P. Kravchuk, D.D. Sheka, Yu. Gaididei, Phys. Rev. B, **84**, 052404 (2011)
[4] All simulations were performed on the computing cluster of Taras Shevchenko university http://cluster.univ.kiev.ua/ using OOMMF micromagnetic modeling code.