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Rectifier Effects in Superconducting /Magnetic Hybrids Based on Ratchet Effects

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Abstract – Nanometric arrays of asymmetric shaped magnetic materials are grown on Si(100) substrates, on top of these arrays a superconducting film is deposited. These hybrids behave as a rectifier in the mixed state with perpendicularly applied magnetic fields; i.e. Injecting an ac current in these hybrids yields an output dc voltage. This effect is based on ratchet phenomena, which appear when an ensemble of particles is driven by zero average forces on asymmetric potentials. These superconducting vortex rectifiers show two possible configurations: longitudinal and transverse and, in the longitudinal case, the rectifier shows reversal of the output voltage polarity.

Magnetic array of asymmetric nanomagnets of submicrometric sizes have been grown on Si (100) substrates by electron beam lithography and sputtering techniques. On top of these arrays a superconducting film is deposited by magnetron sputtering. These hybrids are patterned by etching techniques to a cross-shaped bridge. Magnetotransport measurements are made close to the superconducting critical temperature. Recently, transverse vortex motion rectification effects on superconducting films with arrays of asymmetric defects have been reported [1]. In this device an injected ac current yields an output dc voltage drop in the direction perpendicular to the applied current. The same device shows a rectifier effect in the longitudinal direction, i.e. an applied ac - bias current yields an output dc-voltage in the direction parallel to the applied current [2]. In the former the output signal does not change polarity, but in the latter the polarity could be tune by the amplitude of the ac driving force and for the applied magnetic field (number of vortices on the array). In this work we explore the role played by the frequency, temperature, the array shapes. We show that to enhance the effect the array shape is a crucial parameter as well as the temperature, while the frequency and the type of nanotriangle materials play a minor role.

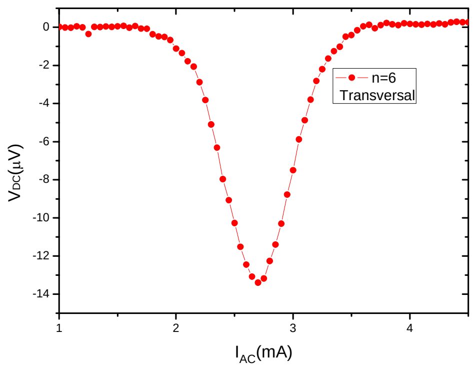

Figure 1: Transverse rectification at T=0.98 T_c, for applied magnetic field which corresponds to 6 vortices per array unit cell. Hybrid is superconducting Nb film on array of Ni nanotriangles.

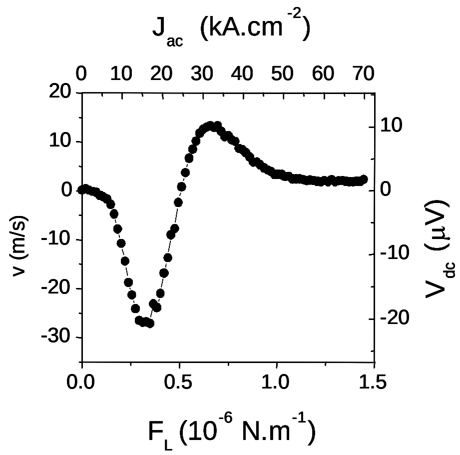

Figure 2: Longitudinal rectification at T=0.98 T_c, for applied magnetic field which corresponds to 6 vortices per array unit cell. Hybrid is superconducting Nb film on array of Ni nanotriangles.

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[2] J. E. Villegas, S. Savelev, F. Nori, E. M. Gonzalez, J. V. Anguita, R. Garcia and J. L. Vicent, Science 302, 1188 (2003).