Vortex dynamics and vortex lattice reconfiguration in superconducting-magnetic hybrids.

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The study of vortex dynamics in type-II superconductors is a challenging field because of the mixed state presents a rich variety of behaviors [1,2]. Interactions between vortices and intrinsic or artificial pinning centers have been the subject of many studies. In this work, amorphous superconducting films (Mo_3Si) have been grown on top of array of nano-metric magnets. These periodic magnetic centers (Fig.1) have been fabricated on Si substrates by Electron Beam Lithography and sputtering techniques. In the mixed state, the competition between the intrinsic and random pinning potential of the superconducting film and the artificial induced periodic pinning potential governs the vortex lattice behavior [3,4]. A classical tool to explore this competition is given by magneto-resistance measurements. The dc measurements were performed in a liquid He^4 cryostat with a superconducting magnet up to 5T. The magnetic field is always applied perpendicular to the substrate and a 40μm wide bridge was used to carry out the resistance measurements (see Fig.2). Close to critical temperature, the periodic potentials could overcome the random potentials, then the vortex lattice dynamics shows collective effects which are related with the array dimension and symmetry. The periodicity in the minima in figures 3 and 4 is related to the corresponding matching field to pin the vortex lattice with the artificial pinning lattice. We will show in these hybrid systems, i.e. Mo_3Si /80 nm Ni dots, enhancements of these matching effects between the vortex lattice and the array unit cell, and different vortex lattice configurations respect to other systems made of superconducting Nb films.

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Figures:

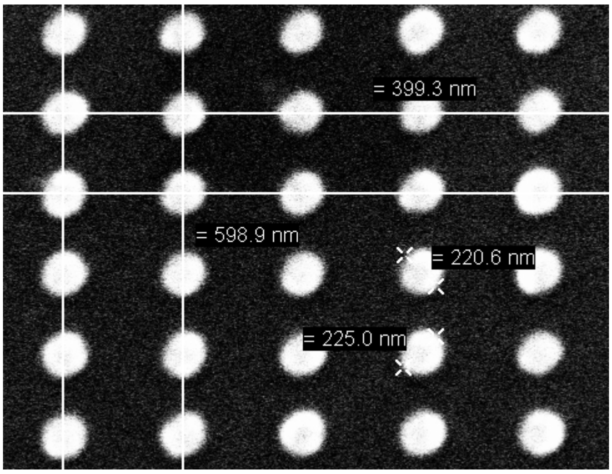

Fig.1. Scanning electron microscope image of 220 nm diameter, 80 nm thick Ni dots in 400 x 600 nm lattice in 100 μm^2 square array.

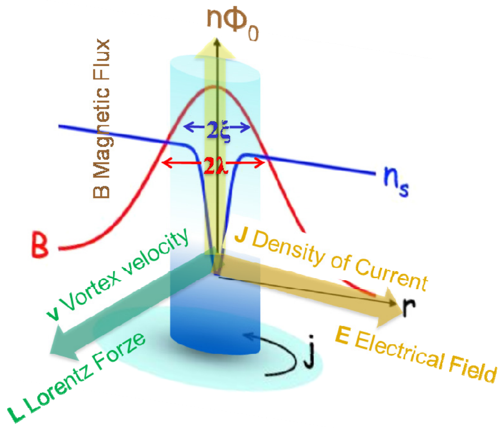

Fig.2. Individual superconductor vortex scheme. The Lorentz Force appears as a consequence of a driven current applied perpendicular to the magnetic flux which is trapped into the vortex.

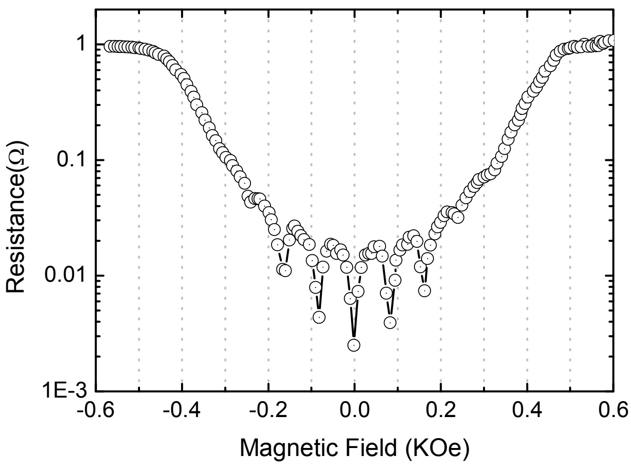

Fig.3. 100 nm Nb film (Tc= 8.2-8.7 K) on top of 80 nm thick, Ni dots in 400 x 600 nm lattice.

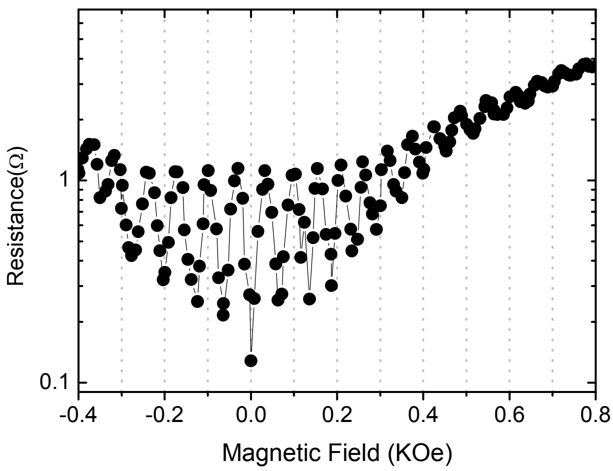

Fig.4. 100 nm Mo_3Si film (Tc= 7.3-7.5 K) on top of 80 nm thick, Ni dots in 400 x 600 nm lattice.