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Vortex Pinning by Symmetric Arrays of Magnetic Nanostructures[1]

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Defects present in a superconducting material can lead to a large variety of static and dynamic vortex phases. In particular, the interaction of a vortex lattice with regular arrays of pinning centers, such as holes or magnetic dots, gives rise to commensurability effects. These commensurability effects can be observed in the magnetoresistance and in critical current dependence with the applied magnetic field. In recent years, experimental results have shown that there is a dependence of the periodic pinning effect on the properties of the vortex lattice and also on the dots characteristics. However, neither the main pinning mechanisms by the magnetic dots nor the dependence on the geometry of the pinning arrays are well understood. To clarify the pinning mechanisms, we studied and compared periodic pinning effects in Nb films with rectangular dot arrays of Ni, Co, Fe and Ni covered with thin Ag layers of varying thicknesses, as well as the pinning effects in a Nb film deposited on a patterned substrate without any magnetic material. We will discuss the differences of pinning phenomena arising from magnetic and structural effects. To clarify the effects of the pinning geometry we studied the vortex-lattice dynamics in Nb films with rectangular arrays of Ni dots. We have performed magnetotransport experiments in which two in-plane orthogonal electrical currents are injected at the same time. This allows selecting the direction and intensity of the resultant driving current on the vortex motion. The background dissipation is angular dependent at low magnetic fields. Increasing the applied magnetic field smears out this angular dependence. The periodic pinning potential locks in the vortex motion along channeling directions. Because of this, the vortex-lattice motion maybe up to 85° off the driving force direction.

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