INTERMEDIATE VORTEX STATE IN NANO-SCALE ANTI-DOTS AND MESOSCOPIC SUPERCONDUCTORS

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We have fabricated anti-dots array in Nb and NbN, and high-Tc superconductor Bi-2212 with the diameter of r and the spacing of a, and have measured the flow-resistance of vortices perpendicular to the array and magnetic field. Depending also to the ratio of r/a, we can produce a variety of vortex-matching effect; the usual and the fractional matching. In low-T_c superconductors, the usual matching effect shows "dips" in the flow resistance at the matching field. However, it shows "humps" at higher magnetic fields, which may be related to the formation of giant vortices and interstitial vortices, depending on the ratio r/a. The matching phenomena seem to occur just like the Bloch electrons in two-dimensional electron system with crystal-line lattice under magnetic field. The anti-dot array acts as a crystalline lattice to the vortices. In this case, vortex flow-resistance corresponds to Tc in the linearlized GL equation. Generation and annihilation of the fractional matching effect might be well reproduced. In high-T_c superconductor, the matching effect is closely related to the first order vortex lattice melting of the pristine samples in the presence of the anti-dot arrays and with changing the potential energy of the vortex pinning.

We also measured the vortex state in mesoscopic type I superconductors of In and Pb. This includes the observation of topological hysteresis with a signature of occurrence in different critical fields during flux entry and exit. We will show the existence of a plethora of metastable configuration and recipes to access them, and demonstrate the manifestation of superheating and supercooling of superconducting and normal states, respectively, across the superconducting transition.