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Self-organized criticality of vortices in superconducting films[1]

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Magnetic flux dynamics in continuous and periodically patterned Nb films is studied using the magneto-optical imaging technique. Slow vortex penetration forming weak flux gradients and smooth flux fronts characterize the magnetization process at elevated temperatures. At low temperatures, microavalanches (irregular jumps of flux bundles with preferential orientation along field gradients) dominate the flux entry and exit and successive redistribution of the vortex density. Thus formed critical state is probed using scaling analysis of the correlation functions, lengths, width, and power spectra of fractal induction profiles in the samples. The resulting Housdorff and roughness exponents correspond to 1+1 dimensional nonlinear flux diffusion in systems with quenched disorder and long range correlations. The power spectra scaling confirms the self-affine character of the dynamically formed critical state. \The nature of the matching effects in periodically patterned samples is reexamined. It is established that neither flat vortex distributions nor terraced states are realized at the fields corresponding to the integer number of vortices per hole. Rather, stronger flux gradients are formed at these fields indicating to the increased average pinning at matching conditions. Macroscopic thermo-magnetic avalanches (TMA) resulting in catastrophic magnetization jumps appear at $T<4.5K$. The sample structure is shown to be crucial for the development of thermally assisted flux instabilities, which follow the topography of the strongest pinning centers in the films. These observations will be analyzed using recent theoretical TMA models. This work was supported by the U.S. Department of Energy, Basic Energy Sciences, under Contract No. W-31-109-ENG-38.

[1]the work with U.Welp, V.Metlushko, and G.W.Crabtree