Inhomogeneous magnetic field penetration in superconducting niobium films

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The slow increase of the external magnetic field typically results in a gradual entry of the magnetic induction into type II superconductor in the form of flux vortices, leading to a formation of a critical state characterized by a gradient of the vortex density, which corresponds to the critical current. However, in thin superconducting films under certain conditions the critical state becomes metastable due to local temperature fluctuations. This leads to the magnetic flux penetration in the form of flux avalanches which propagate much faster than the external magnetic field increases. Such instabilities of magnetic flux can result in the noisy behaviour of magnetization and they lead to the suppression of the apparent critical current density.

In the present work the peculiarities of magnetic field penetration in the form of fingering or dendritic instabilities are studied by magneto-optical technique in the niobium films of different thickness. The distribution of flux vortices in the films is analysed in detail. It is observed that the reduction of Nb film thickness enhances instabilities and reduces the threshold field for instabilities, in agreement with the theoretical predictions [1]. Interestingly, it is shown that the Ag-layer deposited on the top of Nb film leads also to the surprising enhancement of instabilities.

1. D.V. Denisov et al., Phys. Rev. B 73, 014512 (2006).