Dynamics of Magnetic Flux Avalanches in Superconducting Films

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Magnetic flux penetration into superconducting films can occur along two different scenarios: either in the form of homogeneously propagating flux fronts, or as a dendritic instability with branch-like flux avalanches propagating into the previously flux-free reagion of the superconductor. Since the relevant time scale for these processes in the case of thin films is in the nanosecond range, we have developed a fast pump-probe technique for magnetooptic imaging. The method is based on nucleating an event (e.g. the formation of a flux avalanche in a superconductor) by means of a femtosecond "pump" laser pulse, and taking a magnetooptic snapshot of the developing flux distribution by a delayed "probe" beam. The time resolution of this technique is given by the response time of the magnetooptic garnet films used, which in our experiment is about 100ps. Using this technique we have investigated the dendritic instability for various film materials (e.g.$YBa_2Cu_3O_{7-d}$ and MgB_2) and have constructed a "stability diagram" which separates regions with homogeneous flux penetration from unstable ones. In addition we have studied systematically the influence of relevant parameters like film thickness and external magnetic field on the propagation characteristics of the flux dendrites. The experimental results are compared with a theoretical model for dendrite propagation, and good agreement is found.