Magneto-Optical Imaging of Vortices and Flux Avalanches in Superconductors

Tom H. Johansen
Department of Physics - University of Oslo, Norway

Magneto-optical imaging (MOI) is a technique which is based on the large Faraday effect in Bi:YIG films, and has become widely used to study space- and time-resolved magnetic behavior of superconductors. Recently, our group succeeded to bring MOI to a level where individual Abrikosov vortices can be observed and their motion visualized in real-time. I will report on this development, and illustrate by VIDEO clips how MOI can reveal the detailed dynamical behavior of vortex matter. An interesting side effect of using the Bi:YIG sensor is that Bloch walls, commonly present in such films, can be used to actively manipulate vortices. It is shown that such a wall, which basically is a movable nanoscopic bar magnet, can act either as a "vortex brush" or "vortex shovel". The wall can also be used to manipulate other magnetic particles, and micro-magnetic tweezers and squeezers operating on paramagnetic beads will be reported. On a larger scale, MOI has recently discovered that flux penetration in thin film superconductors very often occurs in abrupt bursts of sample spanning (and beautiful!) dendritic flux structures. Various aspects of this avalanche behavior, which manifests also in large noise in M-H loops, will be reported for the cases of MgB2, YBCO and NbN films. Moreover, it will be shown that coexisting with the flux dendrites, which typically involve 106-107 vortices, one finds also well-defined mesoscopic avalanches where 20-10000 vortices participate. In total, the size distribution of avalanches shows two distinct peaks. The distribution of avalanches, their characteristic morphology, as well as their origin will be discussed within the framework of models based on the thermo-magnetic (flux jump) instability.