Highlights

Novel superconducting and functional materials for energy and environment - 2019

Vortex lattice instability at the nanoscale in a parallel magnetic field

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In the present paper, we discuss the influence of sample thickness of few nanometers on the superconducting properties of materials that are commonly used for photon detection applications. In particular, we present experimental results on ultra-thin films of NbN and NbTiN in the presence of in-plane and out-of plane external applied magnetic field. The study focuses on the switching from the superconducting state up to the normal state, which is crucial for the functionality of different photon detectors. In particular, the critical parameters under investigations are related to the abrupt transition that occurs above the critical current in the flux flow state, namely the vortex lattice instability, since a vortex assisted switch to the normal state can be induced by current biasing a thin-film superconducting bridge.
Therefore, different physical quantities have been investigated, such as the critical currents, the switching voltages, the instability currents. However, only in the parallel configuration an unusual "*flying birds*" feature appears in the magnetic field dependence of current switching, as a consequence of the ratio I^*/I_c that is approaching to 1. This amazing tendency becomes relevant for practical applications involving nanostructures, since by scaling down sample thickness and rotating the external field towards the in-plane orientation, the ultra-thin film geometry can mimic the bridge narrowing down to nanoscale.

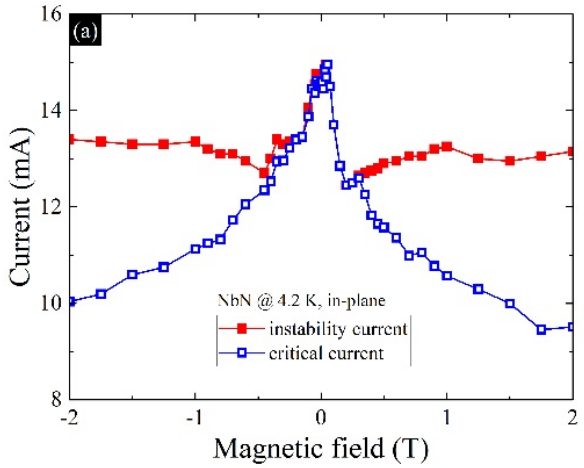

Fig. 1: Instability and critical currents versus magnetic field for the in-plane orientation for NbN sample. This picture reminds a '*flying bird*' and reflects the fact that in the I–V curves there is a threshold field value below which the abrupt jump of vortex instability occurs from the superconducting directly to the normal state.

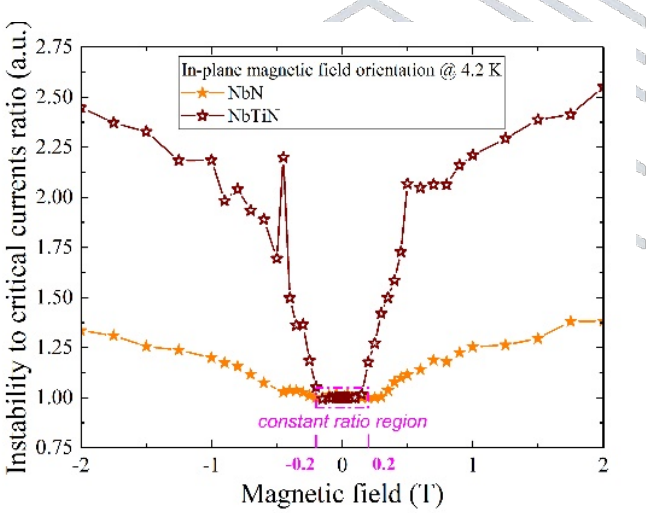

Fig. 2: The ratio I^*/I_c becomes equal to 1 in the presence of quite low fields for the in-plane orientation. This feature can show up when the thickness is downscaled to few *nm*, although the width remains of tens of μm. This '*flying bird*' effect is indeed absent for thicker films.