Highlights

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Current driven transition from Abrikosov-Josephson to Josephson-like vortex in mesoscopic lateral S/S′/S superconducting weak links

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Vortices are topological defects accounting for many important effects in superconductivity, superfluidity, and magnetism. Here we address the stability of a small number of such excitations driven by strong external forces. We focus on Abrikosov-Josephson vortex that appears in lateral superconducting S/S′/S weak links with suppressed superconductivity in S′. In such a system the vortex is nucleated and confined in the narrow S′ region by means of a small magnetic field and moves under the effect of a force proportional to an applied electrical current with a velocity proportional to the measured voltage. Our numerical simulations show that when a slow moving Abrikosov-Josephson vortex is driven by a strong constant current it becomes unstable with respect to a faster moving excitation: the Josephson-like vortex. Such a current-driven transition explains the structured dissipative branches that we observe in the voltage-current curve of the weak link. When vortex matter is strongly confined phenomena as magnetoresistance oscillations and reentrance of superconductivity can possibly occur. We experimentally observe these phenomena in our weak links.

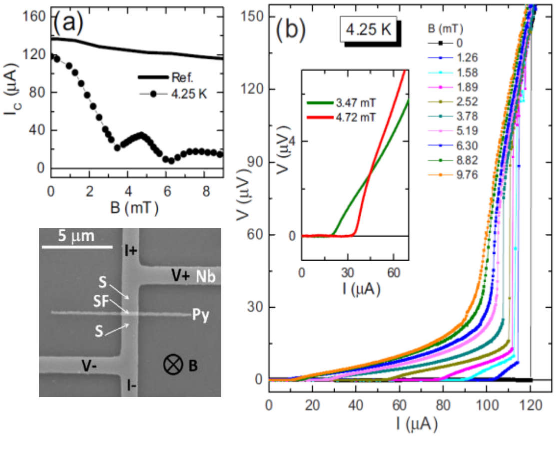

Figure 1. Evidence for critical current oscillations (a) and Abrikosov-Josephson to Josephson-like vortex transition (b). The micrograph of the addressed weak link is also shown in the left bottom image.

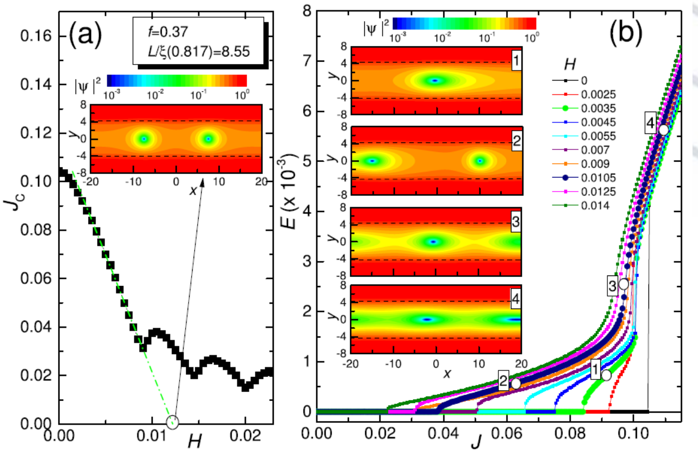

Figure 2. (a) Calculated critical current of the weak link as a function of magnetic field H. The inset is a snapshot of the squared order parameter $|\Psi|^2$ at the marked points of the E(J) curves, showing transition from Abrikosov-Josephson vortex flow (1,2) to Josephson-like vortex flow (3,4)