Nonlocal Electrical Transport in NbN-Based Superconductor/Ferromagnet/Superconductor Microstructures

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Abstract. We present electrical transport measurements through superconductor/ferromagnet/superconductor (S/F/S) microstructures based on superconducting NbN and three ferromagnets with different spin polarizations – NiCu, Ni, and Co. Using a nonlocal four-probe configuration, we observed negative resistance in the normal state for NbN/Ni/NbN and NbN/Co/NbN structures, while the NbN/NiCu/NbN sample exhibited positive resistance. To explain these results, we proposed a simplified six-resistor model based on the Landauer-Büttiker formalism and demonstrated that negative resistance appears when near-surface resistances exceed bulk values.

We further investigated a 160 nm thick NbN film patterned into the same geometry. This sample also revealed negative resistance in the normal state. Moreover, a positive resistance peak near the critical temperature appeared in perpendicular magnetic fields above 5 T. Numerical modeling indicated that this peak originates from a difference in the superconducting transition width (ΔT_c) between the surface and bulk regions.

These results revealed that nonlocal through-film measurements are highly sensitive to the differences of the transport properties between surface and bulk regions in both normal and superconducting states.

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