Anomalous zero-bias conductivity in superconductor-ferromagnet-insulator-superconductor tunnel junctions

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There has been increasing interest in ferromagnet-superconductor heterostructures. One of the not well understood phenomena is the presence of a weak supercurrent at zero voltage bias in S_1/F-I-S_2 junctions (here S, I, and F denote a superconductor, an insulator, and a ferromagnetic metal, respectively) without any sign of the energy gap of the S_1/F electrode in the tunneling conductance.[1] Here we present results of an experimental and theoretical study of the $Nb_{(1)}$/Ni/Al-AlO_x-Al/$Nb_{(2)}$ heterostructures with increased (comparing to that reported in Ref. 1) thickness of the Ni layer. At low temperatures, their electrical characteristics reveal the presence of a zero-bias anomaly that can be associated with the Josephson current. This anomaly, as well as the absence of a gap feature of the $Nb_{(1)}$/Ni bilayer, is explained in terms of phase-coherent charge transport through a disordered ferromagnetic film with an elastic mean free path being less than its thickness, d_F, whereas the phase breaking length exceeds d_F.

[1]A. A. Bannykh, J. Pfeiffer, V. S. Stolyarov, *et al.* Phys. Rev. B **79**, 054501 (2009).