

Competition between superconductivity and magnetism in ferromagnet/ superconductor heterostructures

Izyumov Y., Proshin Y., Khusainov M.

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

The mutual influence of superconductivity and magnetism in F/S systems, i.e. systems of alternating ferromagnetic (F) and superconducting (S) layers, is comprehensively reviewed. For systems with ferromagnetic metal (FM) layers, a theory of the proximity effect in the dirty limit is constructed based on the Usadel equations. For an FM/S bilayer and an FM/S superlattice, a boundary-value problem involving finite FM/S boundary transparency and the diffusion and wave modes of quasi-particle motion is formulated; and the critical temperature T_c is calculated as a function of FM- and S-layer thicknesses. A detailed analysis of a large amount of experimental data amply confirms the proposed theory. It is shown that the superconducting state of an FM/S system is a super-position of two pairing mechanisms, Bardin-Cooper-Schrieffer's in S layers and Larkin-Ovchinnikov-Fulde-Ferrell's in FM ones. The competition between ferromagnetic and antiferromagnetic spontaneous moment orientations in FM layers is explored for the 0- and π -phase superconductivity in FM/S systems. For FI/S structures, where FI is a ferromagnetic insulator, a model for exchange interactions is proposed, which, along with direct exchange inside FI layers, includes indirect Ruderman-Kittel-Kasuya-Yosida exchange between localized spins via S-layer conduction electrons. Within this framework, possible mutual accommodation scenarios for superconducting and magnetic order parameters are found, the corresponding phase diagrams are plotted, and experimental results are explained. The results of the theory of the Josephson effect for S/F/S junctions are presented and the application of the theory of spin-dependent transport to F/S/F junctions is discussed. Application aspects of the subject are examined. © 2002 Uspekhi Fizicheskikh Nauk, Russian Academy of Sciences.

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