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SUPERCONDUCTIVITY

Distribution of Pairing Functions in Superconducting Spin Valve SF1F2

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Abstract—The distribution of the spin-singlet component, the short-range spin-triplet component with zero projection, and the long-range spin-triplet component with projection ±1 of the superconducting pairing function has been obtained for different regimes of switching of a spin valve with a three-layer heterostructure (superconductor/ferromagnet/ferromagnet). The distribution of the components is discussed as the main reason for the behavior of the superconducting transition temperature as a function of the angle between the magnetic moments of the ferromagnetic layers in these regimes.

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1. INTRODUCTION

The superconducting transition temperature T_c was analyzed [1] for a three-layer heterostructure SF1F2, where S is a singlet superconductor and F1, F2 are ferromagnetic metals, in which the long-range triplet superconducting component is formed for noncollinear orientation of the magnetizations of the F layers. The asymptotically exact numerical method was used for calculating T_c as a function of the three-layer structure parameters, such as mutual orientation of magnetizations, transparency of boundaries, and layer thickness [2]. Earlier, it was shown in [3] that T_c of the semi-infinite heterostructure SF1F2 can be a nonmonotonic function of angle α between the magnetizations of two F layers in contrast to the monotonic behavior of the $T_c(\alpha)$ dependence obtained for the FSF model of the superconducting spin valve [4]. The existence of an anomalous dependence of the spin-triplet correlations on angle α in the FFS structure in the ballistic case was predicted in [5] (the layer thickness was much smaller than the correlation length of the material of these layers). In this research, we consider the distribution of amplitudes of spin-singlet and spin-triplet pair correlations as functions of the layer thickness for different values of angle α between magnetizations in the SF1F2 structure in order to determine how and which of the distributions affects the superconducting transition temperature T_c.

2. MODEL AND NUMERICAL METHOD

Let us first find the dependence of T_c of the SF1F2 structure (Fig. 1) on angle α between the exchange fields of two F layers.

Suppose that the S layer of thickness d_S lies in the region $-d_S < x < 0$, the middle layer F1 of thickness d_{F1} lies in the region $0 < x < d_{F1}$, and the outer layer F2 of thickness d_{F2} lies in the region $d_{F1} < x < d_{F1} + d_{F2}$. The x axis is assumed to be normal to the plane of the layers. The exchange field of the middle layer F1 lies in

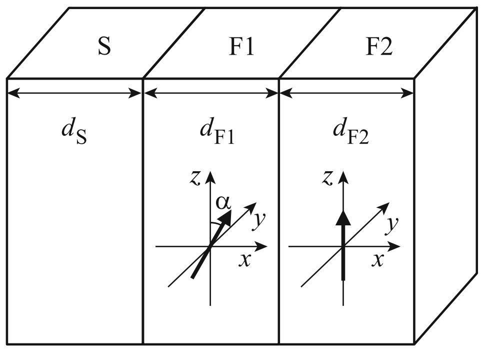

Fig. 1. Three-layer heterostructure SF1F2. The SF1 contact boundary corresponds to coordinate $x = 0$. Bold arrows in F layers indicate the direction of **h** exchange fields lying in yz plane.