Interplay between spin-singlet and spin-triplet ordering in SFF spin valves

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Recently, structures where two F-layers are coupled to a superconductor (FSF or SFF) attracted much attention since they may serve as superconducting spin valves, where transition temperature is controlled by angle α between F-layer magnetization directions. In this work we address the issue of interplay between spin-singlet and spin-triplet superconducting correlations in SFF structures. We show that that the magnetization-induced phase slips at both interfaces lead to a number of new phenomena. First, for parallel orientations of magnetizations in the F-layers, π-state in SFFIS Josephson junction can be realized as a result of two subsequent $\pi/2$ phase shifts at the interfaces. Second, the magnitude of long-range spin-triplet order parameter component generated in SFF structures with varying angle α, has anomalous dependence on α. Namely, contrary to the standard knowledge based on the analysis of symmetric FSF or SFFS structures, the triplet component in SFF structures does not reach a maximum in the vicinity of $\alpha = \pi/2$ but it vanishes for this configuration of magnetization vectors. We also discuss how these new effects manifest itself in the conductance of F layers and in the realization of $0 - \pi$ transition in SFFIS tunnel junctions.