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Experimental observation of the triplet spin-valve effect in a superconductor-ferromagnet heterostructure

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Abstract

The theory of superconductor-ferromagnet heterostructures with two ferromagnetic layers predicts the generation of a long-range, odd-in-frequency triplet pairing at noncollinear alignment (NCA) of the magnetizations of the F layers. This triplet pairing has been detected in a Nb/$Cu_{41}Ni_{59}$/normal conducting- (nc-) Nb/Co/CoO_x spin-valve-type proximity effect heterostructure, in which a very thin Nb film between the F layers serves as a spacer of nc metal. The resistance of the sample as a function of an external magnetic field shows that for not too high fields, the system is superconducting at a collinear alignment of the $Cu_{41}Ni_{59}$ and Co layer magnetic moments but switches to the normal conducting state at a NCA configuration. This indicates that the superconducting transition temperature T_c for NCA is lower than the fixed measuring temperature. The existence of a minimum T_c, at the NCA regime below that one for parallel or antiparallel alignments of the F-layer magnetic moments, is consistent with the theoretical prediction of a singlet superconductivity suppression by the long-range triplet pairing generation.