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Probing Magnetism by Superconductor in Proximity

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We have investigated the T_c behavior of heterostructures made from superconductor(S), normal metal(N), and ferromagnetic metals(F). The T_c of SF bilayers has been measured with a resolution of 20 mK and the results have been quantitatively analyzed by proximity effect in SF bilayers, namely the FFLO state. By using three different ferromagnetic materials, CoFe, Ni, and CuNi, with distinctly different Curie temperature, we have been able to provide accurate numbers for the exchange energies in the FFLO model. In addition, from the precise measurement of the interface parameters, we characterized the interfaces of Nb/CoFe, Nb/Ni, and Nb/CuNi. Subtle differences of these interfaces will be described. Extension of the SF bilayer work has been made by inserting a normal (N) layer between the S and the F layers. We have used Au, Cu, and Al as the N layer and came up with completely different behavior, due to the different interface parameters, γ_b, of the NF interfaces. Especially the very large γ_b value, about 4, of the Al/CoFe interface is difficult to understand in the conventional Usadel picture of SF proximity effect, especially considering the spin-rotation, a general phenomenon at the magnetically active interface. We introduced a new concept of triplet superconductivity to explain the large γ_b value at the Al/CoFe interface and will present evidences for a uniqueness of Al in its spin properties. Furthermore we will present more recent experimental work involving density of state measurement by tunneling spectroscopy and a new heterostructures involving S, F, and N layers.

keywords : proximity, ferromagnet, Usadel, triplet superconductivity