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Triplet supercurrents in ferromagnets[1]

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In almost all superconductors the pairs of electrons which carry the charge are in the so-called singlet state in which the quantum spin of the two electrons is antiparallel. During the past five years there has been increasing evidence that proximity coupling between singlet superconductors and ferromagnets can sometimes generate triplet pairs within the ferromagnet in which the spins of the electrons are parallel rather than antiparallel – the evidence being that supercurrents can be passed through thicknesses of ferromagnetic material which are simply too large for singlet pairs to survive. The superconductor-ferromagnet proximity effect describes the fast decay of a spin-singlet supercurrent originating from the superconductor upon entering the neighboring ferromagnet. For strong ferromagnets such as Co, a thickness of only a few nanometres is sufficient to almost completely suppress the critical current of a Nb/Co/Nb Josephson junction. Here we report experiments in which a conical magnet (holmium) is placed at the interface between the superconductor and ferromagnet. The results showed that a long-ranged supercurrent can occur through the ferromagnetic Co layer but only for certain critical thicknesses of the Ho [1]. These thicknesses correspond to maximum magnetic inhomogeneity on the Ho and are therefore consistent with models which predict that a spin-mixing interface between the superconductor and ferromagnet can generate triplet pairs which are long-ranged in the ferromagnet. This paper reports recent experiments which aim to understand further the behaviour of triplet pairs in superconductor / ferromagnet heterostructures.

[1] J. W. A. Robinson, J. D. S. Witt, and M. G. Blamire, "Controlled Injection of Spin-Triplet Supercurrents into a Strong Ferromagnet" Science **329**, 59-61 (2010).

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