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Observation of spin-triplet supercurrent in Co-based Josephson junctions[1]

NORMAN BIRGE, Michigan State University

When a superconductor (S) and a ferromagnet (F) are put into contact with each other, the combined S/F system may exhibit altogether new properties. There is a proximity effect where pair correlations from S penetrate into F, but these correlations decay over a very short distance due to the large exchange splitting between the spin-up and spin-down electron bands in F. Theory predicts that, under certain conditions, electron pair correlations can be generated with spin-triplet rather than spin-singlet symmetry [1]. The two electrons in such a spin-triplet pair have parallel spins and are not subject to the exchange splitting in F; hence they propagate long distances. We have measured a long-range supercurrent in Josephson junctions of the form S/X/N/SAF/N/X/S, where S is a superconductor (Nb), N is a normal metal (Cu), SAF is a synthetic antiferromagnet of the form Co/Ru/Co, and X is a thin ferromagnetic layer necessary to induce spin-triplet correlations in the structure [2]. Spin-triplet correlations are generated due to non-collinearity of the magnetizations in each X layer and the nearest Co layer. Using X = PdNi, CuNi, and Ni, we observe enhancements of the critical current of up to 300 times relative to similar samples lacking the X layers. We also observe a large additional enhancement of the spin-triplet supercurrent after the samples are magnetized in a large field. This result is counter-intuitive, since one would expect magnetizing the samples to suppress the occurrence of non-collinear magnetization. We will present a model of the SAF magnetization structure that explains these intriguing results.

[1] F.S. Bergeret, A.F. Volkov, and K.B. Efetov, Phys. Rev. Lett., 86, 4096 (2001).
[2] T.S. Khaire, M.A. Khasawneh, W.P. Pratt, Jr., N.O. Birge, Phys. Rev. Lett. 104, 137002 (2010).

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