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Crossed Cooper Pair Transmission and Pure Spin Supercurrents through Strongly Spin-polarized Ferromagnets

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Interfaces between solids with different ordering phenomena have become a focus of research in recent years. One reason is that new and unexpected phases that are not stable in either of the adjacent materials can appear in the interface regions. The mechanism for creating such phases is due to induced symmetry breaking, as opposed to spontaneous symmetry breaking in the bulk materials. As a prominent example I discuss interface-induced exotic superconductivity in heterostructures composed of conventional singlet superconductors and strongly spin-polarized ferromagnets. I present new intriguing effects, such as a tunable pure spin-supercurrent in a strongly spin-polarized ferromagnet contacted with only one superconducting electrode, and a difference in the critical currents for positive and negative bias in a high transmission ferromagnetic Josephson junction [1]. The latter, rather surprising effect has a physical explanation in terms of a new "crossed Cooper pair transmission" process. In this process two singlet Cooper pairs are coherently decomposed into two equal-spin triplet pairs, which are respectively transmitted via different spin bands in the ferromagnet, after which they again recombine into two singlet pairs. This effect is analogous to the well-known crossed Andreev reflection process, which however is strongly suppressed in this particular case. Furthermore, I discuss how the manipulation of interface spins can be used to pump triplet pairs. This opens an avenue for new types of superconducting quantum devices and new ways to test properties of exotic superconducting phases in experiment.

[1] R. Grein, M. Eschrig, G. Metalidis, and G. Schön, Phys. Rev. Lett. **102**, 227005 (2009).