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Coexistence of, and Competition between, Magnetism and Superconductivity[1]

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Magnetism and superconductivity are competitive types of order in correlated electron systems. However, when a magnetic material is brought in contact with a superconducting material to build a junction, a coexistence region exists near the boundary that can modify the properties of the heterostructure in a qualitative way. In the case of a ferromagnet in contact with a singlet superconductor, the importance of triplet pairing correlations in the interface region recently became the focus of research. Such triplet correlations have unusual properties. They are typically odd in frequency for the case of a diffusive material. For clean materials in addition a triplet component even in frequency but odd in momentum is present. We have predicted that such triplet correlations can lead to an unusual indirect Josephson effect in a superconductor/half-metal/superconductor structure. In the case of a long half-metal such a Josephson effect is solely due to equal-pair triplet superconducting correlations. The triplet supercurrent is converted into a singlet current in the interface regions of the structure. Although theoretically predicted, a direct experimental verification of the presence of triplet correlations in ferromagnet/superconductor hybrid structures is difficult. In addition to the above effect we propose to use the torque on a ferromagnet/superconductor/ferromagnet trilayer in an external magnetic field as a probe of the presence of triplet correlations in the superconducting phase.

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