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Spin-orbital coupling in a triplet superconductor—ferromagnet junction

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We predict a novel form of interaction between spin and orbital degrees in a spin-triplet superconductor (TSC)- ferromagnet (FM) heterostructure (see Fig. a). In such a system the orientation of the FM moment relative to the TSC vector order parameter is a crucial variable that controls the main physical properties. In addition to the pair breaking, spin-flip reflection processes at the interface with the FM scatter the triplet Cooper pairs between the spin up and down condensates, setting up an effective Josephson-like coupling between them. The pair-breaking and spin Josephson coupling both make significant contributions to the free energy of a TSC-FM junction through the proximity effect, the interface electronic reconstruction, and the variation of the TSC gap. Although these contributions depend upon the direction of the FM's exchange field, the two effects do not necessarily act constructively. For a single-component p-wave TSC, we find that the variation of the gap controls the orientation of the FM's moment via the change in condensation energy. The stable configuration is either parallel or perpendicular to the TSC vector order parameter, depending on the alignment of the TSC gap with respect to the interface, thus evidencing a unique form of spin-orbital coupling. The competing orbital components of the chiral p_x+ip_y state generate a non unique behavior and a first-order transition from the perpendicular to the parallel configuration as the FM exchange field is increased (see Fig. b). When the interface is imperfect the scenario is different and other processes can play a relevant role in setting the magnetic profile.

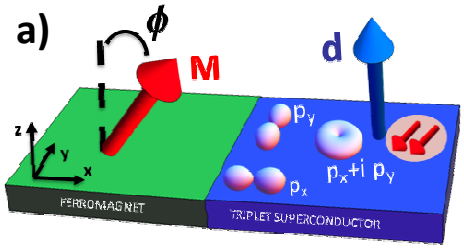

Fig. a) Schematic diagram of the two-dimensional TSC-FM junction. The magnetization M of the FM can form an angle Φ with respect to the d-vector of the TSC. We study TSC states with p_x, p_y and p_x+ip_y orbital symmetry.

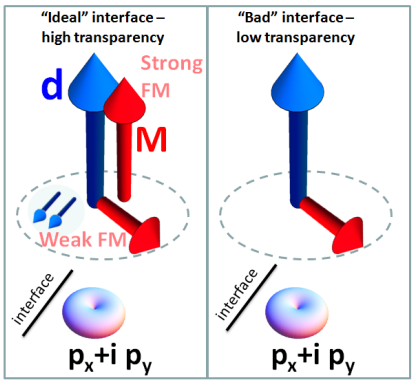

Fig. b) Sketch of the most favorable ferromagnetic orientation in the case of a chiral spin-triplet superconductor.