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Equal-spin supercurrents and magnetization dynamics in high-temperature superconductor/ferromagnet hybrids

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Superconductivity and magnetism are antagonistic phenomena whose competing interaction results in novel states and unusual properties that, beyond their fundamental interest, present much potential for rupture technologies. One of the promising examples is the so-called superconducting spintronics, which aims at marrying the spin-polarized transport characteristic of ferromagnets with the dissipationless, quantum-coherent transport of superconductors. We will focus on two different facets of that problem. On the one hand, we well describe experiments on the propagation of superconducting correlations into ferromagnets. In particular, we will demonstrate long-range Josephson coupling across the half-metallic manganite La0.7Sr0.3MnO3 combined with the high temperature superconducting d-wave cuprate YBa2Cu3O7. That is shown in planar junctions that display large critical currents and the hallmark Josephson characteristics: modulation of the critical current due to magnetic flux quantization and quantum phase locking effects under microwave excitation [1]. On the other hand, we will detail experiments on spin diffusion into superconductors. This is investigated using wideband ferromagnetic resonance in bilayers that combine a soft metallic Ni80Fe20 (Py) ferromagnet and YBa2Cu3O7. We find that the Gilbert damping exhibits a drastic drop as the heterostructures are cooled across the normal-superconducting transition, and then a strong upturn that indicates efficient spin pumping into the superconductor. This unique behavior is explained considering quasiparticle density of states at the YBCO surface, and is a direct consequence of zero-gap nodes for particular directions in the momentum space [2]. Our results demonstrate, the potential of high-temperature superconductors for the practical realization of superconducting spintronics, and for fine tuning of the magnetization dynamics of ferromagnets.

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