Superconductor-Antiferromagnet-Superconductor Junction

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Josephson junction via a magnetic interlayer is a widely studied system, which exhibits a spectrum of intriguing phenomena. These include length and temperature induced 0-pi transitions for ferromagnetic junctions, anomalous phase shift $\varphi_0 \neq 0$ for ferro- and antiferromagnetic junctions with spin-orbital interaction, as well as junctions via textured magnets. Typically, for long magnetic junctions the transport of superconducting current hinges on long-range correlations, specifically spin-1 Cooper pairs, as only these pairs could penetrate deeply into the magnetic layer.

In this work, we investigate a 2D SAFS Josephson junction through a layered antiferromagnet. It is assumed to be composed of two atomically thin layers of opposite magnetization. When traveling in one of the layers, spin-zero Cooper pairs become strongly suppressed at the characteristic magnetic length due to magnetic decoupling. Nevertheless, it could be expected that non-local pairs, whose electrons move in different layers of the antiferromagnet would not suffer magnetic decoupling, and thus could penetrate the depth of the magnet and carry non-zero current. In this setup, we study how currents through the layers of antiferromagnets depend on the transparency of the interlayer interface. By studying the dependence of junction's critical current on magnetization and junction length, we demonstrate that the current indeed is carried by non-local Cooper pairs. We propose a way to observe this effect by applying external magnetic field to the junction. This investigation advances our understanding of unconventional current transport in Josephson junctions via layered antiferromagnets.