MAR16-2015-000227

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Finite Momentum Pairing and Spatially Varying Order Parameter in Proximitized HgTe Quantum Wells

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Conventional s-wave superconductivity is understood to arise from singlet pairing of electrons with opposite Fermi momenta, forming Cooper pairs whose net momentum is zero. Several recent studies have focused on structures where such conventional s-wave superconductors are coupled to systems with an unusual configuration of electronic spin and momentum at the Fermi surface. Under these conditions, the nature of the paired state can be modified and the system may even undergo a topological phase transition. Here we present measurements and theoretical calculations of several HgTe quantum wells coupled to either aluminum or niobium superconductors and subject to a magnetic field in the plane of the quantum well. By studying the oscillatory response of Josephson interference to the magnitude of the in-plane magnetic field, we find that the induced pairing within the quantum well oscillates between singlet and triplet pairing and is spatially varying. Cooper pairs acquire a tunable momentum that grows with magnetic field strength, directly reflecting the response of the spin-dependent Fermi surfaces to the in-plane magnetic field. Our new understanding of the interplay between spin physics and superconductivity introduces a way to spatially engineer the order parameter, as well as a general framework within which to investigate electronic spin texture at the Fermi surface of materials.