Supercurrent-enabled Andreev reflection in a chiral quantum Hall edge state

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A chiral quantum Hall (QH) edge state placed in proximity to an s-wave superconductor experiences induced superconducting correlations. Recent experiments have observed the effect of proximity-coupling in QH edge states through signatures of the mediating process of Andreev reflection. We present the microscopic theory behind this effect by modeling the system with a many-body Hamiltonian, consisting of an s-wave superconductor, subject to spin-orbit coupling and a magnetic field, which is coupled by electron tunneling to a QH edge state. By integrating out the superconductor we obtain an effective pairing Hamiltonian in the QH edge state. We clarify the qualitative appearance of nonlocal superconducting correlations in a chiral edge state and analytically predict the suppression of electron-hole conversion at low energies (Pauli blocking) and negative resistance as experimental signatures of Andreev reflection in this setup. In particular, we show how two surface phenomena of the superconductor, namely Rashba spin-orbit coupling and a supercurrent due to the Meissner effect, are essential for the Andreev reflection. Our work provides a promising pathway to the realization of Majorana zero-modes and their parafermionic generalizations.