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Investigation of hybrid Josephson junctions for topological applications

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Hybrid superconductor/semiconductor devices constitute a powerful platform where intriguing topological properties can be investigated. Here we present Josephson junction devices formed by a high-mobility InAs quantum-well bridging two Nb superconducting contacts. We demonstrate supercurrent flow with transport measurements, high critical temperature of 8.1 K, and critical fields of the order of 3T. Modulation of supercurrent amplitude can be achieved by acting on two side gates lithographed close to the two-dimensional electron gas. Low-temperature measurements reveal well-developed quantum Hall plateaus, showing clean quantization of Hall conductance and demonstrating the potential of hybrid devices to investigate the coexistence of superconductivity and Quantum Hall effect. Moreover, we present a different, fully tunable, hybrid semiconductor/superconductor device, in which the width, area, and supercurrent of the two arms of a SQUID-like geometry can be independently controlled with high precision. We show that one can tune the device from one extreme case to another: from a SQUID with narrow arms to a Fraunhofer pattern in an extended single--armJosephson junction. Transition between these limits is investigated in a continuous manner, via electrostatic gating, without the need of additional in-plane magnetic field. Comparison between experimental results and a simple theoretical model is discussed.

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