Emergent anomalous metallic phase in InAs-Al nanowires due to inverse proximity effect

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Hybrid superconductor-semiconductor nanostructures have attracted great attention in the past decade as a platform for the development of new quantum devices with added functionalities. Some examples include hybrid superconducting qubit architectures such as the gatemon [1], the Andreev spin qubit [2], the hybrid fluxonium [3], the gatemonium [4], etc. In addition, this material platform has been intensively studied experimentally for the realization of topological superconductivity [5], which holds promise for the development of noise-resilient qubits.

Here, we study an effect on the hybrid materials above that has been largely overlooked: the inverse superconducting proximity effect imparted by normal metals electrically contacting the nanostructures. In this context, our work reveals a type of *observer effect*, whereby the superconducting properties of a nanostructure are affected by connecting it to electrical leads for measurements. In this work, we study such an *observer effect* on devices based on full-shell hybrid superconductor-semiconductor InAs-Al nanowires. Our observations indicate that the inverse superconducting proximity effect leads to the formation of "weak spots" along the wire, resulting in a sharp reduction of the switching current and the emergence of an anomalous metallic phase with low but finite resistance. Using the Little-Parks effect as a knob to tune superconductivity, we test this hypothesis and find an excellent agreement between the experimental data and a model based on the Usadel theory of diffusive superconductors. This *observer effect* might explain other instances of anomalously small switching currents measured in hybrid superconductor-semiconductor devices [6,7] and serve as a source of disorder in low dimensional superconductors hindering technological applications.

References

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