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Josephson Effect in Graphene: a Tunneling Spectroscopy Study

LANDRY BRETHEAU, JOEL I-JAN WANG, RICCARDO PISONI, Department of Physics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, United States, KENJI WATANABE, TAKASHI TANIGUCHI, National Institute for Materials Science, Namiki 1-1, Tsukuba, Ibaraki 305-0044, Japan, PABLO JARILLO-HERRERO, Department of Physics, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, Massachusetts 02139, United States — A normal conductor placed in good contact with a superconductor can inherit its electronic properties. This proximity effect in the conductor originates from the formation of entangled electron-hole states, called Andreev states. Spectroscopic studies of Andreev states have been performed in just a handful of systems. Graphene provides a novel platform for studying Andreev physics in two dimensions because of its large mobility, ease of access and electrostatically tunable carrier density. Using a full van der Waals heterostructure, we have performed direct tunnelling spectroscopy of proximitized graphene. The measured energy spectra, which depend on the phase difference between the superconductors and on graphene carrier density, reveal a continuum of Andreev bound states. We further infer the supercurrent they carry from the phase dependence of the spectra, thus relating Andreev physics and the Josephson effect. As graphene's extended two-dimensional nature enables one to combine superconductivity and the quantum Hall effect, this platform is promising for the detection of Majorana modes, key ingredients for topologically protected quantum computation.

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