Superconducting proximity effect in long superconductor/graphene/superconductor junctions : From specular Andreev reflection at zero field to the quantum Hall regime

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Abstract

A superconductor-graphene(SG) hybrid system, such as an SGS junction or an SG interface, provides an ideal platform to investigate the relativistic nature of Dirac fermions combined with superconductivity. Instead of the retro-reflection of carriers in an ordinary superconductor-normal metal interface, an SG interface is theoretically predicted to show the specular reflection of quasiparticle carriers.

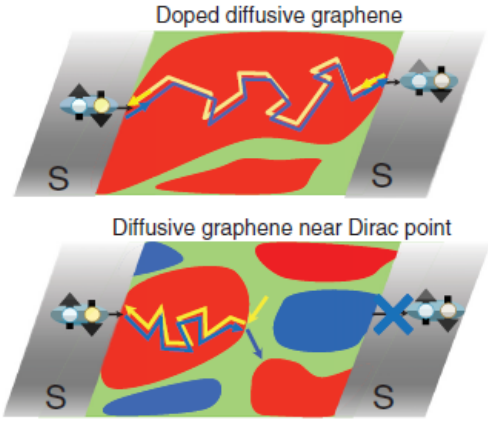
We show that a supercurrent flows through a SGS junction with Nb electrodes even through a very long graphene distance of 1.2 micron, more than 3 times the length previously reported. This supercurrent disappears in the vicinity of the Dirac point, indicating a strong sensitivity of the transmission of Andreev pairs to the formation of charge puddles with size greater than the superconducting coherence length.

We also present data on similar size graphene samples with superconducting electrodes with a high critical field (more than 7Tesla) for which the properties of the normal state are dominated by quantum Hall physics. Whereas the behavior of the superconductor is similar to the Nb/Graphene/Nb system in zero field, new features are observed in the high field quantum Hall regime.

Reference

[1] Katsuyoshi Komatsu, Chuan Li, S. Autier-Laurent, H. Bouchiat, S. Guéron Phys. Rev. B **88**, 115412 (2012).

Figure



Sketch of the superconducting proximity effect through diffusive graphene, at high and low doping. (Top) Highly doped regime. The usual Andreev retroreflection at the S/G interface leads to diffusive counterpropagation with zero total phase accumulation. (Bottom) Low-doping regime. SpecularAndreev reflection of propagating Andreev pairs can occur at an $n/0$ or $p/0$ junction, leading to loss of counterpropagation and thus large phase accumulation within an Andreev pair. Supercurrent, which results from all Andreev trajectories, is destroyed. The red region is electron doped, the blue one is hole doped, and the green region in between has nearly zero doping.