

Abstract

In light of recent experimental advances, we explore the charge transfer process across a monolayer Graphene - Superconductor interface in graphene-based Josephson junctions. Our methodology is based on the transfer matrix method which is used to obtain the analytical expressions for the Andreev bound states (ABS) including the effects of retro Andreev reflection (RAR) and specular Andreev reflection (SAR) in different parameter regimes. We analytically derive the expressions for calculating the Josephson current and the conductance of the junctions using the ABS spectrum and compare them with some of the available experimental data for different values of the bias voltages and junction lengths. We find a good agreement between the theory and the experimental results and observe a scaling behaviour of the current and the conductance with respect to the junction length. We also discuss the role of SAR and RAR in determining the magnitude of the current and conductance in various parameter ranges. We extend these calculations to the SGSGS Josephson junction arrays and study the effect of the interference at different SG interfaces on the transport properties of the junction array, taking into account the retro and specular aspects of the Andreev reflection processes.

We also investigate the electrical properties of a Graphene - Superconductor - Graphene (GSG) hybrid structure, where a superconducting region is induced in the middle of a graphene sheet, in contrast to the widely studied electrical properties across a Superconductor-Graphene-Superconductor (SGS) type of Josephson junction. Using a method based on the transfer matrix, we mainly examine the Goos-Hänchen shift for the electrons and the holes at the GS interface in such a structure due to normal and Andreev reflection. Furthermore, we calculate the normalised differential conductance as a function of bias voltage that describes the transport through such junctions and highlight how Andreev and normal reflection affect them.