Stationary Josephson effect in ballistic graphene junctions: effects of inhomogeneous carrier density

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We report our recent study on the stationary Josephson effect in ballistic mono- and bi-layer graphene junctions. In order to capture features specific to the graphene junctions, we model the system as a planar Josephson junction,[1] in which two superconducting electrodes are deposited on ([bi-layer case] the top layer of) a graphene sheet. A tunneling Hamiltonian is then employed to describe the coupling between the graphene layer and the superconducting electrodes. We assume that a constant potential $-U$ is present in the region covered by the superconductors and take account of the fact that the carrier density is higher (lower) in the covered (uncovered) region. Applying the quasi-classical Green's function approach, we find a general expression for the Josephson current valid whenever the chemical potential is away from the Dirac point. The obtained formula holds true for arbitrary U and coupling strength Γ in the mono- and bi-layer cases. We further investigate the behavior of Josephson critical current I_c at zero temperature in the large-Γ limit. We find that the decrease of I_c with increasing U is more pronounced in the bilayer case than in the monolayer case, reflecting contrasting electronic properties of a potential junction in mono- and bi-layer graphene sheets.

[1] Y. Takane and K.-I. Imura, J. Phys. Soc. Jpn. **80**, 043702 (2011).