Visualization of Electron and Hole Trajectories in Normal-Superconductor Junction Using Scanning Gate Microscopy Technique

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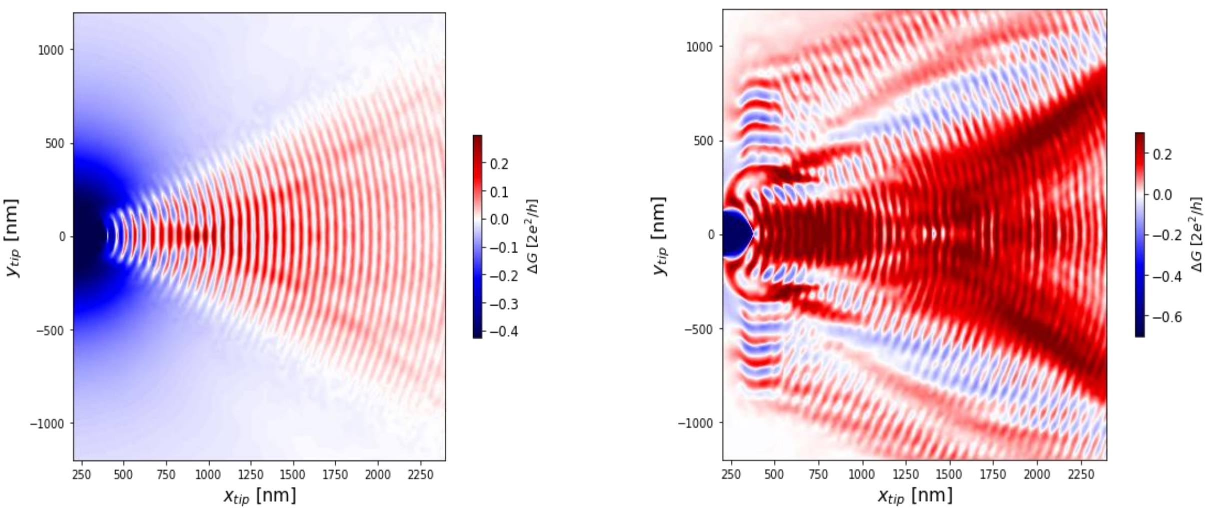
We perform theoretical analysis of the electron and hole trajectories probing within a two-dimensional Normal-Superconductor (NS) junction embedding a quantum point contact (QPC) via scanning gate microscopy (SGM) technique. In normal systems, SGM is a widely used method to visualize the branched electron flow [1]. In our work, taking advantage of the recent progress in the realization of NS junctions in gated heterostructures [2], we propose to use this method to trace the paths of electrons and Andreev-reflected holes. We find that in an NS junction, the conductance probed by the SGM exhibits oscillations that are due to the self-interference of electrons and holes. In contrast to ordinary SGM measurements, the interference occurs between the QPC and the SGM tip and between the tip and the NS interface. Most importantly, we show that for the measurements performed at a nonzero bias, the oscillations are beating with the two periods determined by the two Fermi wavelengths corresponding to the electron and hole wave vectors. Finally, we show that at nonzero bias, the hole's trajectory deviates from the electron path due to the difference in the incident and reflection angles at the NS interference, resulting in a distinct interference pattern in the conductance map [see Fig. 1].



A) Zero bias

B) Non-zero bias

Fig. 1: Electron-hole interference in SGM conductance maps.

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