Non-local spectroscopy of topological superconductivity in Josephson junctions

Dibyendu Kuiri[1*], Michal P. Nowak[1]

[1]*Academic Centre for Materials and Nanotechnology, AGH University of Krakow, Krakow, Poland*

*corresponding author: kuiri@agh.edu.pl

One of the biggest challenges in modern solid-state physics is to identify indicators of topological superconductivity and to detect the elusive Majorana-bound states. Hybrid nanostructures – Josephson junctions realized on a two-dimensional electron gas – are being considered as promising candidates for developing topological elements that are easily controllable and scalable [1,2,3]. Here we theoretically study the possibility of detection of topological superconductivity via non-local spectroscopy technique. We show that the non-local conductance is related to the system's band structure and allows to probe the gap closing and reopening related to the topological transition. We show that the topological transition induces the change of the sign of the non-local conductance at zero energy due to the change of the quasiparticle character of the bands at zero momentum. Importantly, we show that the evolution of superconducting phase difference in hybrid Josephson junctions is strongly influenced by the strength of the Zeeman interaction, which leads to considerable modifications in the complete phase diagram that can be measured in realistic experiments.

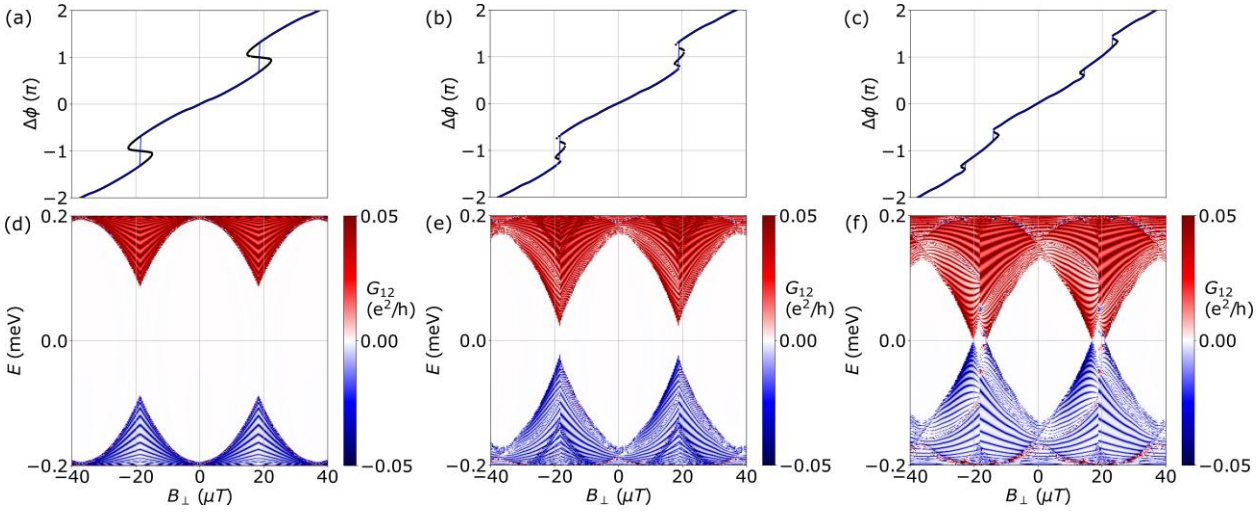

Fig. 1. Numerical flux to phase conversion for parallel magnetic field 0, 0.5 and 1 T as shown in (a), (b) and (c) and corresponding spectroscopy maps shown in (d), (e) and (f) respectively. Only for strong Zeeman interaction the gap closing and reopening is present.

[1] F. Pientka, A. Keselman, E. Berg, A. Yacoby, A. Stern, and B. I. Halperin, Phys. Rev. X **7**, 021032 (2017).

[2] M. Hell, M. Leijnse, and K. Flensberg, Phys. Rev. Letter. **118**, 107701 (2017)

[3] C. M. Moehle, P. K. Rout, N. A. Jainandunsing, D. Kuiri, C. Ting Ke, D. Xiao, C. Thomas, M. J. Manfra, M. P. Nowak, S. Goswami, Nano Letters **22**, 8601 (2022).