Self-heating effects and switching dynamics in graphene multiterminal Josephson junctions

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Multiterminal Josephson junctions (MTJJs) consisting of a single scattering region connected to multiple superconducting terminals were shown to exhibit non-trivial topology and simulate the band structure of Weyl semimetals [1]. Furthermore, recent experimental advances led to the observation of hybridized ABSs [2], signatures of quartet supercurrents [3,4], the Josephson diode effect [5] and topological phase transitions [6].
We experimentally investigate the electronic transport properties of a three-terminal graphene Josephson junction. We find that self-heating effects strongly influence the behaviour of this MTJJ system. We show that existing simulation methods based on resistively and capacitively shunted Josephson junction networks can be significantly improved by considering these heating effects. We also investigate the phase dynamics in our MTJJ by measuring its switching current distribution and find correlated switching events in different junctions. We show that the switching dynamics is governed by phase diffusion at low temperatures. Furthermore, we find that self-heating introduces additional damping which results in overdamped I-V characteristics when normal and supercurrents coexist in the device.

References

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[3] A. H. Pfeffer, et al., Phys. Rev. B 90, 075401 (2014).
[4] E. G. Arnault, et al., Nano Letters 22, 7073 (2022)
[5] J. Chiles, et al., Nano Letters 23, 5257 (2023)
[6] E. Strambini, et al., Nature Nanotechnology 11, 1055 (2016)

Figures

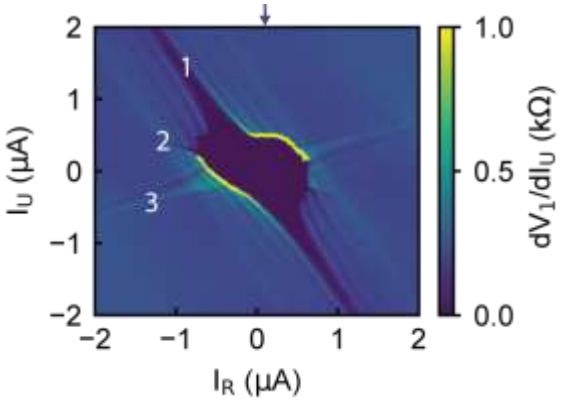

Figure 1: Measured differential resistance map of the 3-terminal Josephson junction.

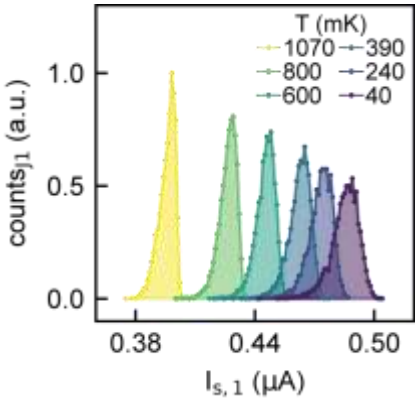

Figure 2: Switching current distribution of the 3-terminal Josephson junction as a function of bath temperature.