Nonlocal thermoelectricity in topological Josephson junctions

Gianmichele Blasi[1], Fabio Taddei[1], Liliana Arrachea[2], Matteo Carrega[1,2] and Alessandro Braggio[1]

[1] *NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Piazza San Silvestro 12, Pisa I-56127, Italy*
[2] CNR-SPIN, Via Genova, Italy
alessandro.braggio@nano.cnr.it

We consider a Josephson junction hosting a Kramers pair of helical edge states of a quantum spin Hall bar in contact with a normal-metal probe. In this hybrid system, the orbital phase induced by a small magnetic field threading the junction known as Doppler shift (DS), combines with the conventional Josephson phase difference and originates an effect akin to a Zeeman field in the spectrum. As a consequence, when a temperature bias is applied to the superconducting terminals, a thermoelectric current is established in the normal probe[1]. We argue that this purely non-local thermoelectric effect is a unique signature of the helical nature of the edge states coupled to superconducting leads and it can constitute a useful tool for probing the helical nature of the edge states. In this configuration, we investigate how the flux bias and the phase bias trigger the nonlocal thermoelectric effects under the application of a thermal difference between the superconducting terminals.[2] Possible experimental nonidealities such as asymmetric proximized superconducting gaps are considered showing how the nonlocal response is affected. The interplay between Doppler-shift, which tends to close gaps, and Andreev interferometry, which affects particle-hole resonant transport, are clearly identified for different operating regimes.[3] Finally, we discuss the power and the efficiency of the topological nonlocal thermoelectric engine which reaches maximum power at maximal efficiency for a good coupled normal probe. We finally prove quite high nonlocal Seebeck coefficient of the order of tenths of μV/K at a few kelvins, a signal that would be clearly detectable also against any spurious local effect even with moderate asymmetry of the gaps.

References

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[3] G. Blasi, F. Taddei, L. Arrachea, M. Carrega, and A. Braggio, arXiv:2103.14394

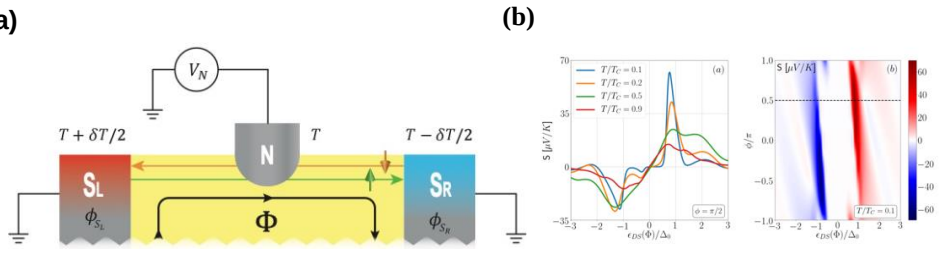

Figure 1. (a) Nonlocal thermoelectrical setup in a topological Josephson junction. (b) Nonlocal Seebeck effect of the topological Josephson junction as a function of flux bias(Doppler shift)[left figure] and phase bias [right figure]