Topology, twisting and thermal rectification in one and two dimensions

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For many applications relevant to energy harvesting and management it is important to control the heat transport across devices. For instance, using different carbon isotopes in graphene can lead to a significant reduction of the thermal conductivity without affecting the electronic properties [1]. This is particularly useful as a tool to maximize the so-called ZT figure of merit, which is proportional to the ratio of the electrical conductivity to the thermal conductivity. Using in-plane isotope superlattices in graphene, we showed experimentally that ZT can be greatly enhanced [1]. In a simple 1D analogue, we showed that an isotope superlattice has also non-trivial topological properties, which can lead, not only to a suppression of the thermal conductivity, but also to the appearance of thermal rectification [2], i.e., the heat current in one direction is different from the heat current in the opposite direction as shown in figure 1. We further generalize these results to other topologies, including twisted graphene other isotope superlattices.

References

[1] E. Whiteway, M. Lee, M. Hilke, Graphene isotope superlattices with strongly diminished thermal conductivity for thermoelectric applications, ACS Applied Nano Materials 3 (9), (2020), 9167-9173
[2] A. Alseiari, M. Hilke, Thermal rectification with topological edge states, arXiv:2312.12374, (2023)

Figures

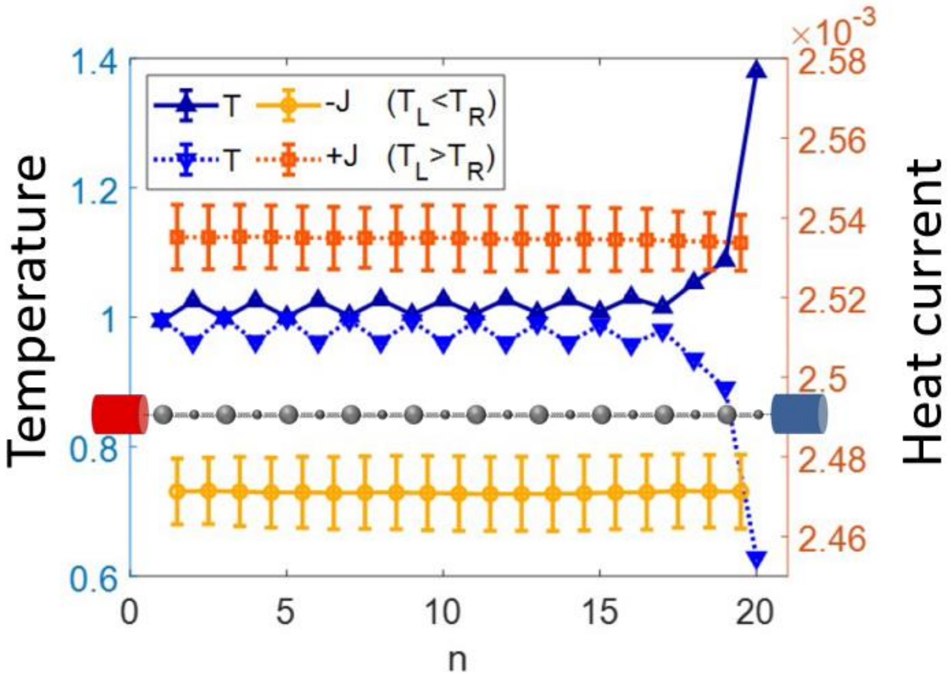

Figure 1: Temperature dependence along an even number isotope superlattice chain (N = 20), where the alternating masses have mass 2 and 0.5. The absolute values of the heat currents are also shown for the two cases, where the temperature difference is inverted, leading to heat rectification.