Spatially-resolved dissipation in a quantum wire with a coherent scatterer

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The recent advent of astonishing measurement techniques allows the near-atomic resolution of tiny local temperature changes, even three orders of magnitude lower than the sample temperature itself [1]. The new approaches confirmed earlier estimations that dissipation (accompanying electric current) is not shared equally among two 1d wires attached to a point contact. Moreover, the formation of so called heat-spots (small and confined areas of increased temperature) were observed in the quantum regime [2]. Evidently, dc charge transport possesses the key to further unravel the microscopic mechanisms behind spatial dissipation profiles.

Based on a model of two 1d wires sandwiching a scatterer (Fig 2 (a)), we studied the spatial profile of the dissipated power (Fig 2 (b)) for generic transmission of the scatterer. We present the mechanism behind the formation of heat/ cold spots and the key role of the electric potential, which is required to maintain the electric current against the increased wire's resistivity in close vicinity to the point contact.

References

[1] D. Halbertal et al., Nature 539 (2016) 407
[2] Q. Weng et al., Nat. Commun. 12 (2021) 4752

Figures

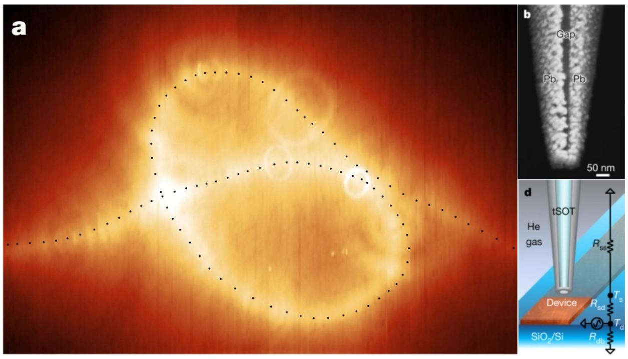

Figure 1: Thermal imaging a current carrying carbon nanotube (dots) using the SQUID-on-tip technique (tSot). Picture from [1].

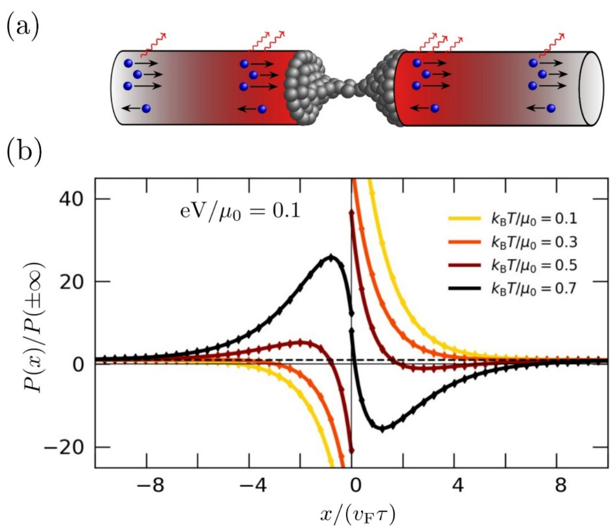

Figure 2: Simulating the local power profile around quantum scatterers. (a) Sketch of the model. The transmission probability of the scatterer (gray) yields an energy loss of the electrons (blue) in the wires (red). (b) Calculated dissipation profile for a Lorentzian transmission at various temperatures and fixed voltage drop inside the scatterer. Low temperatures (black) show the presence of heat (cold) spots as local maximum (minimum).