Non-equilibrium electron interference for power generation

Waste heat can be converted into useful power by using the thermoelectric effect. A temperature difference drives electrons against a potential difference between two terminals when two requirements are met: an incoming heat flow and that electron-hole symmetry is broken in the junction connecting the two terminals. Two important scales that are generally overlooked in thermoelectric devices are the *coherence* and the *thermalization* lengths: typically electrons relax in distances much shorter than the system size, so each component of the conductor has a well defined temperature. This is the regime of classical thermoelectrics.

The opposite regime, where the system is small compared to the coherence and the thermalization lengths, is largely unexplored. Due to the first condition, electrons maintain their phase when propagating through the system. The resulting quantum interference is able to break electron-hole symmetry. Due to the second condition, electrons injected in the system may not have a thermal distribution (and hence no well defined temperature). This way, non-equilibrium rather than heat can be used as a thermodynamic resource.

This work proposes to investigate the interplay of these two effects in configurations where non-thermal electrons are injected into a nanoscale conductor. The aim is to find the conditions to generate power in an electron-hole symmetric system with no injected heat. A candidate configuration is a nanowire coupled to a scanning tunneling microscope (STM). The tip injects non-equilibrium electrons locally, as sketched in the figure, hence introducing position-dependent interference-induced power patterns.

The approach is to propose simple models based on scattering theory that capture the relevant physics and can be solved analytically. More involved configurations can be addressed numerically.

The project will be supervised by:

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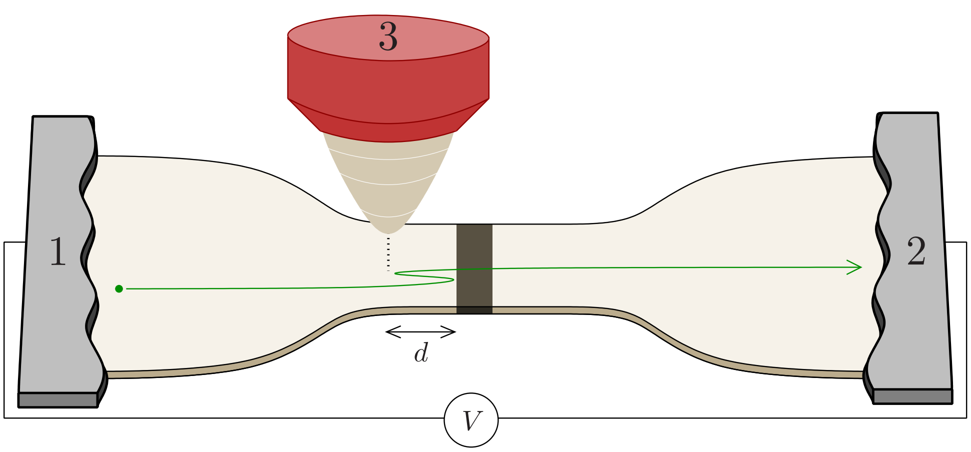

Figure 1: Local injection of non-equilibrium from a STM tip into a quantum conductor. Interference of scattering trajectories gives rise to a thermoelectric-like voltage along the conductor.