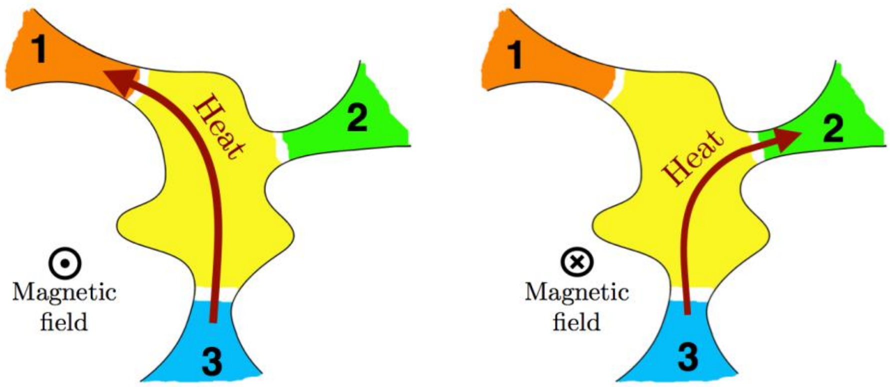
Quantum Transport and Thermodynamics

Since the industrial revolution, the transformation of heat into work has been at the centre of technology. The earliest examples were steam engines, and current examples range from solar cells to nuclear power stations. The quest to understand the physics of this transformation led to the theory of thermodynamics.
in recent years we have become increasingly interested in machines that convert heat into electrical power at a microscopic level. The perfect example of this are thermoelectric and photovoltaic devices. Nanotechnology has significantly advanced efforts in this direction, giving us unprecedented control of individual quantum particles. The questions of how this control can be used for new forms of heat to work conversion has started to be addressed in recent years.
This scientific activity has been boosted by the increasing importance placing on sustainable energy for the world's population. On the one hand, heat management at the nanoscale could dramatically reduce the energy cost of operating electronic devices and nanoscale scalable thermal engines could efficiently convert part of the waste heat into electricity. On the other hand, efficient thermoelectric Peltier cooling would underpin wide range of quiet, long-lived refrigeration devices, with low environmental impact.
Our main objective is to better understand the laws of nature. More particularly, we aim to better understand what heat and entropy mean for quantum objects, and to better understand how such objects thermalize. We also aim to understand what quantum machines can be capable of, and what the laws of physics do not allow. At the same time, more practical goals include using ideas from quantum transport and quantum thermodynamics to devise more efficient thermal rectifiers, thermoelectrics and photovoltaics.



A model of a magnetic thermal switch for nanoscale heat management [for details see Phys. Rev. B 91, 205420 (2015)]

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References:

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