Centre for
Theoretical Atomic, Molecular and Optical Physics
CTAMOP
Queen's University Belfast

Ph.D. Project 2019-2022

Heat transport in quantum devices

Project supervisor: **Dr Gabriele De Chiara**
Contact: **g.dechiara@qub.ac.uk**

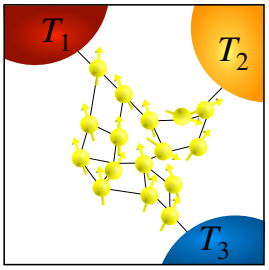
State of the art and motivations

Many phenomena in nature can be described by spontaneous transfer of energy due to a temperature difference. For example a warm coffee left in a cup will gradually cool down due to energy exchange with the surroundings until the temperature of the coffee reaches an equilibrium. Modelling the cooling mechanism of quantum objects is pivotal for studying dissipation processes affecting quantum devices, e.g. quantum computers.

Objectives & Methodology

The objective of the project is to model heat transport in small quantum devices. These could be embodied by a network of qubits connected to several thermostats with a temperature T_i, as shown in the diagram. The action of the thermostats will be modelled using so-called *Lindblad master equations* and memory (non-Markovian) effects on the energy flow will be explored.

Once the modelling stage is completed, the next goal is to investigate how energy flow between different parts of the network can be controlled and optimised. One can, for instance, control the heat flow between two thermostats, amplifying, suppressing and inverting it, by acting on a third terminal thus realising a quantum heat valve or transistor. Calculations will be performed both analytically and numerically.



Collaborations

Expected theoretical collaborations include Prof. Anna Sanpera (Universitat Autonoma de Barcelona), Prof. John Goold (Trinity College Dublin), Prof. Gabriel Landi (Univ. of São Paulo). We will also collaborate with experimental teams in Denmark (Prof. J. Sherson) and Switzerland (Dr T. Donner).

Required skills

A solid knowledge of quantum theory and at least one programming language.

Further information

The student will be a member of the Quantum Technology group at Queen's University Belfast and will participate to its activities (group meetings, seminars, meetings with guest scientists) and it is expected the participation at international conferences and schools.

For further information, please contact Dr De Chiara g.dechiara@qub.ac.uk.

References

[1] Adam Hewgill, Alessandro Ferraro, Gabriele De Chiara, *Quantum correlations and thermodynamic performances of two-qubit engines with local and collective baths*, Phys. Rev. A **98**, 042102 (2018).

[2] Noah Linden, Sandu Popescu, and Paul Skrzypczyk, *How Small Can Thermal Machines Be? The Smallest Possible Refrigerator*, Phys. Rev. Lett. **105**, 130401 (2010).

[3] Lucas Schuab, Emmanuel Pereira, and Gabriel T. Landi, *Energy rectification in quantum graded spin chains*, Phys. Rev. E **94**, 042122 (2016).