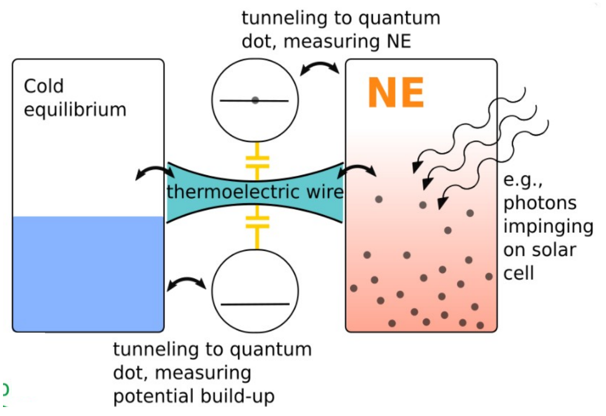
Master thesis or internship project:
Feedback-driven optimization of hot-carrier solar cells

Student profile: Master students in theoretical physics (or similar master programs).

Duration: Projects from 5-12 months are possible.

Contact: Bruno Bertin-Johannet (Bruno.bertin-johannet@chalmers.se) and Janine Splettstoesser (janines@chalmers.se), Applied Quantum Physics Division, Department of Microtechnology and Nanoscience at Chalmers.



Example for feedback in a solar cell device. Two quantum dots are measuring the occupation in the electronic contacts and are capacitively coupled to a thermoelectric wire. The information about the contact occupation stored in the quantum dots is used to steer the properties of the thermoelectric wire.

The group "Dynamics and thermodynamics of nanoscale devices" in the Applied Quantum Physics division of the department of Microtechnology and Nanoscience at Chalmers is looking for a motivated student to investigate the potential implementation of a feedback mechanism in a hot-carrier solar device within a theoretical-physics master project.

In solar cells, photons impinge on a semiconductor and excite electron-hole pairs, which can be extracted in different collectors. This generates electrical power, by driving a current against a voltage bias or across a load. In general [1], generated electron-hole pairs go through many different energy-loss processes before they can be extracted, which is detrimental to the efficiency of the cell. A promising route to reduce this effect is provided by *hot-carrier* solar cells, in which energy-filters are used in order to quickly and selectively extract electrons at high energies. In these devices, as similar effect is used as the one underlying thermoelectric devices [2].
In order to further improve the performance, we here propose to investigate the potential of so-called "autonomous feedback" mechanisms, measuring the energy-distribution of electron-hole pairs and subsequently influencing the thermoelectric properties of the solar cell. This feedback mechanism needs to take account for the very different time-scales governing the physics of the solar cell, reaching from long time-scales on which the illumination conditions change to very short time scales of electron relaxation.

This project is a theory project, the main tool used will be a quantum master equation approach combined with simple numerical simulations. We however also foresee that discussions with experimentalists in the field, both at Chalmers as well as at Lund University., will benefit the progress of the project.

References:

[1] D. König, *et al.*, *Hot carrier solar cells: Principles, materials and design,* Physica E: Low-dimensional Systems and Nanostructures **42,** 2862 (2010).
[2] L. Tesser, R. S. Whitney, and J. Splettstoesser, *Thermodynamic Performance of Hot-Carrier Solar Cells: A Quantum Transport Model,* Phys. Rev. Applied **19**, 044038 (2023).