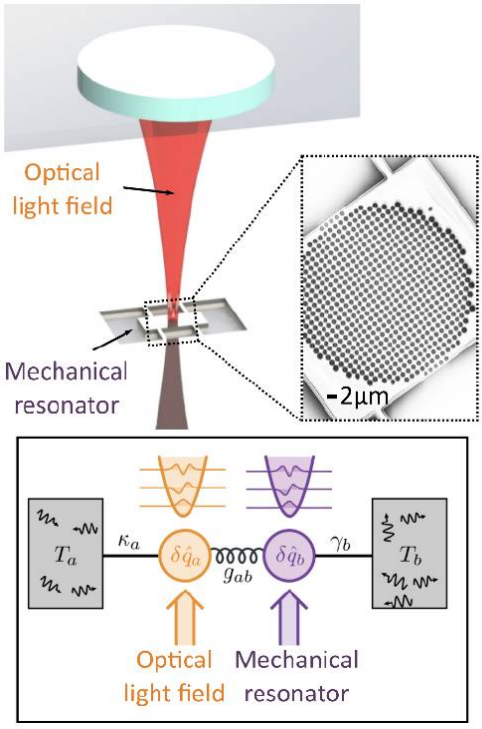
Energy harvesting
with a nano-optomechanical heat engine

Contact: Janine Splettstoesser (AQP), janines@chalmers.se
Witlef Wieczorek (QT), witlef.wieczorek@chalmers.se

Project description:



A major question of sustainable technologies is how to harvest waste heat and how to produce "useful" energy from it. With the rise of nanotechnology, researchers also start to investigate how to harvest heat at the nanoscale - possibly directly "on-chip". The nano-optomechanical device shown in the figure is an intriguing example for this, where one expects that heat can be absorbed from an optical bath and successively used to produce electrical or mechanical work. Standardly, one theoretically describes heat engines using the theory of thermodynamics, which was developed more than a century ago to describe massive, macroscopic machines. For nano devices of our interest, a completely new picture arises: instead of macroscopic statistics, quantum fluctuations play a decisive role and are expected to lead to new functionalities.

Optomechanical systems provide a unique possibility to study heat engines. This project investigates how the quantum properties of this device can be exploited for heat-to-work conversion. In this setup, the optical light field acts as an engineered heat bath. The working medium is a mechanical resonator, whose energy can be harvested by coupling to electronic degrees of freedom. We will calculate the heat flow between the device elements and find optimal conditions for an efficient heat-to-work conversion. Another intriguing question is whether such a system allows to implement a so-called Maxwell demon, which seemingly iolates the second law of thermodynamics by reducing a system's entropy without doing any work on it.

During this project, you will become familiar with the concept and theoretical description of heat engines in nanoscopic systems. The main goal of the project is the proposal and the analysis of a theoretical model for a nanomechanical heat engine based on an optomechanical system and to use this to analyze the above-mentioned research questions. This model shall be based on experimental parameters, which correspond to experiments in adjacent fields currently set up at QT, MC2.

Literature tips

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