QSUN Quantum Research Group of Stellenbosch University

SA QuTI South African Quantum Technology Initiative

NITheCS National Institute for Theoretical and Computational Sciences

Stellenbosch University iYunivesithi Universiteit

SEMINAR

Nonequilibrium quantum heat transport between structured environments

Dr Graeme Pleasance (Stellenbosch University)

Friday, 31 January 2025 @ 15h00-16h00 SAST

Venues: Online and Physics Seminar Room, Stellenbosch University

ABSTRACT

The study of nonequilibrium dissipative systems is central to understanding quantum heat transport in nanoscale devices. Over the last few decades, the nonequilibrium spin-boson model (NESB) has been employed as a paradigmatic model of heat transport in anharmonic nanojunctions consisting of a single spin-1/2 system embedded between two thermal baths. While this setup has provided key insights into the fundamentals of nanoscale heat devices, its applications so far have mainly focused on structureless, Ohmic baths.

In this talk, I will discuss an extended version of the NESB where the usual Ohmic baths are augmented with pairs of coupled harmonic oscillators. It is demonstrated that the steady-state heat flow in this setup follows a substantially different scaling law in the asymptotically weak coupling limit compared to the case in which the heat transfer is mediated by a single oscillator. In particular, a second-order treatment of the currents fails to capture the correct steady-state behaviour in this regime, which stems from the λ^4-scaling of the current to lowest order in the coupling strength λ. On the other hand, the current noise follows the same scaling for both cases in accordance with the fluctuation-dissipation theorem. Finally, I will show the steady-state current of the augmented model to be consistent with Fourier's law even at large temperature bias. Our results highlight the possibility of controlling heat transport via reservoir engineering techniques, which based on recent experiments, could be feasibly implemented using superconducting circuits.

BIOGRAPHY

Graeme Pleasance is a postdoctoral researcher in the Quantum@SUN group at Stellenbosch University. He graduated with an MSci in Theoretical Physics from the University of Birmingham in the UK in 2013, and received his PhD from the University of Sussex in 2018. From 2018 to 2022, he held a postdoctoral research position in the Quantum Research Group at the University of KwaZulu-Natal. His current research focuses on the development of non-perturbative techniques for treating strongly-coupled open quantum systems, with applications to thermodynamics.

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