Review of quantum transport could pave the way to improved energy management at the nanoscale

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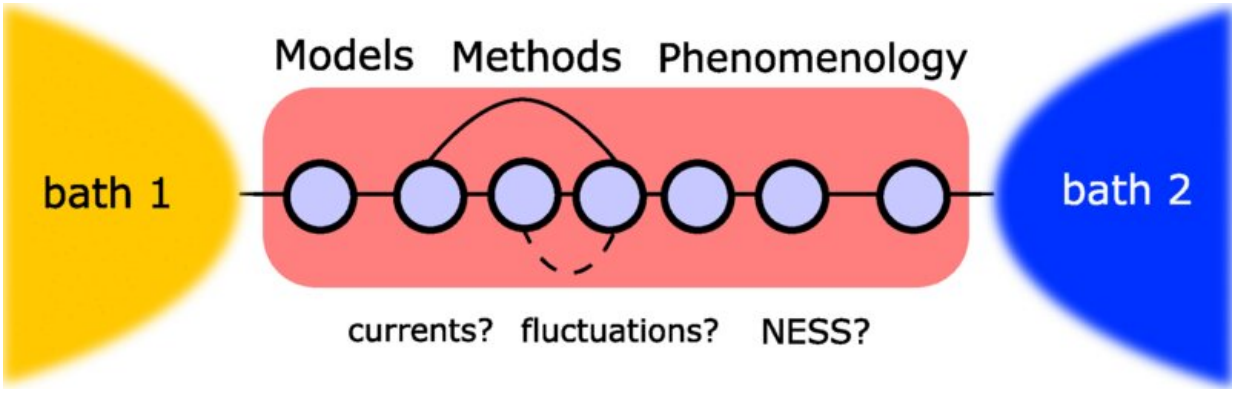

Boundary-driven systems are composite open systems that are locally coupled to external baths (yellow left and blue right) and internally via a Hamiltonian. This enables nonequilibrium steady states (NESSs) characterized by stationary currents. Credit: *Reviews of Modern Physics* (2022). DOI: 10.1103/RevModPhys.94.045006

The quantum effects of physics have become increasingly important in the advancement of communications, computing and sensing in speed, power and precision like never before.

Through quantum mechanics, we can study the quantum effects—the physics of the transportation of intricate quantities such as particles,

magnetization and energy. This can potentially spur the development of novel and powerful nanoelectronics, such as thermal diodes.

The field of quantum transport has been well established, with about 100 years of research invested into advancing the discipline. However, the vast amount of available data as well as the complexity of the systems make reviewing and assessing the information an arduous task.

To bridge this gap, researchers from the Singapore University of Technology and Design (SUTD) collaborated with Instituto de Física da Universidade de São Paulo and Helmholtz-Zentrum Dresden-Rossendorf to publish a review paper in the *Reviews of Modern Physics* titled, "Non-equilibrium boundary-driven quantum systems: Models, methods and properties," that provides an overview of the theoretical understanding of quantum systems.

"While a significant amount of research has been undertaken, the information has not been clearly organized. This makes it difficult for the research community to provide relevant contributions, share common pitfalls and may discourage potential researchers from entering the field.

"This review provides students and experts alike with the accessibility to better structured information, allowing for deeper insights that could in turn foster more research innovations," said principal investigator Associate Professor Dario Poletti from SUTD.

The review focuses on nanoscopic systems, which couple with the environment in a way that a current could be forced to go through them. It is sectioned into three parts: how to model quantum transport setups, how to study them with analytical or numerical methods, and the expected phenomenologies. In particular, the pros and cons of the models and methods were discussed.

Assoc. Prof. Poletti also explained that the main results from key setups were assessed, laying the groundwork for anyone in the field of quantum transport, even those who are just starting out, to understand what has been done, where to find more detailed information, the long-standing open problems and how one could try to address them.

"This review will further empower the research community to ask the most pressing questions and tackle the most pressing issues in quantum transport. Consequently, we will be able to figure out better energy management at the nano scale which can, in turn, create a more sustainable future for us," added Poletti.

More information: Gabriel T. Landi et al, Nonequilibrium boundary-driven quantum systems: Models, methods, and properties, *Reviews of Modern Physics* (2022). DOI: 10.1103/RevModPhys.94.045006

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