Non-Markovian Effect on Quantum Transport

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The recent developments of nano-fabrication technology enable the downsizing of various kinds of devices to quantum regimes[1], stimulating studies on nano-electronics[2], phononics[3], and quantum thermodynamics[4], to name a few. One of the elementary processes required in the studies is to control quantum transport in a finite time. In particular, when we consider speeding up transport, we need to treat the time scale before approaching a stationary state comparable or shorter to the relaxation time of transported entities. In the time scale, it is necessary to surmount the conventional Markovian approximation to describe the relaxation assuming the correlation time to be infinitely short, and consider the finiteness of the correlation time of the environmental variables to provide the non-Markovian effect. In this talk, we present the role of the non-Markovian effect in taking some kinds of quantum transport.

The first case to be presented is the acceleration and controllability of quantum energy transport by using the non-Markovian effect[5] based on the model proposed to describe the possibility of environmental assistance of energy transport (ENAQT) in the light-harvesting antenna of a photosynthetic bacteria. While the original ENAQT model describes the assistance of energy transport by the environmental noise with the white spectrum, we extend it to a stochastic process with spatial as well as temporal correlation to find the anti-spatial with temporal correlation noise accelerates quantum energy transport.

Secondly, we present the non-Markovian feature found in energy transport between a system and its environment[6]. While the conventional treatment under Markovian approximation shows that the energy in the relevant system is dissipated in one-way into the environment, we found the possibility of partial backflow of energy from the environment by considering the non-Markovian effect, corresponding to the partial reversibility. Extension of the simple model to the quantum Otto engine shows that the energy backflow can be an origin to increase the extracted work[7].

If time permits, we will also present the non-Markovian effect in spin transport.

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