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要旨集

２０２１年７月１３日（火）

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物理学第一分野ＤＣ３回生研究発表会

場所：理学研究科５号館　５階・第四講義室＋オンライン
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２０２１年7月１３日（火）１１：３０～　開始

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Pumping current in a non-Markovian N-state model

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Abstract A periodically modulated N-state model whose dynamics are governed by a time-convoluted generalized master equation is theoretically analyzed. The non-Markovian master equation is converted to a larger Markovian model affording easy analysis. The behavior of this model is investigated by calculating the cycle-averaged pumping current analytically and numerically.

Master equations (MEs) are widely used in non-equilibrium statistical mechanics to model the time evolution of a range of classical and quantum mechanical systems. In their basic form, MEs only describe systems that carry no memory of their past: this property is referred to as Markovianity. It is known, however, that due to a number of physical reasons, real systems do usually possess some degree of memory of their past evolution, and thus obey a non-Markovian ME (nMME) [1].

Modulating control parameters such as reaction rate coefficients, bath temperatures or gate voltages of a physical system out of equilibrium can lead to net flow of a physical current, known as Thouless pumping [2]. The origin of the pumping current is the Berry-Sinitsyn-Nemenman (BSN) phase, which was originally discovered in the context of quantum systems [3]. The BSN phase is a geometrical effect which also exists in classical systems, such as the Sinitsyn-Nemenman (SN) model of reaction kinetics, in which some parameters are cyclically modulated by an external agent [4].

Motivated by these results, in the present study a generalization of the SN model obeying a nMME is presented as a natural extension of the conventional SN model, and mapped onto a larger Markovian system. We demonstrate that a good agreement is achieved between the pumping current obtained from the numerical solution, and the analytically calculated geometrical current in the adiabatic limit. Furthermore, we employ a technique based on eigenvalue analysis and perturbation theory to go beyond the adiabatic limit and show the improvement on the analytical calculation that results from accounting for the effect of finite modulation speed [5]. Fig. 1 shows a schematic of the Markovian system used for the calculations and a plot of the modulation speed dependence of the pumping current.

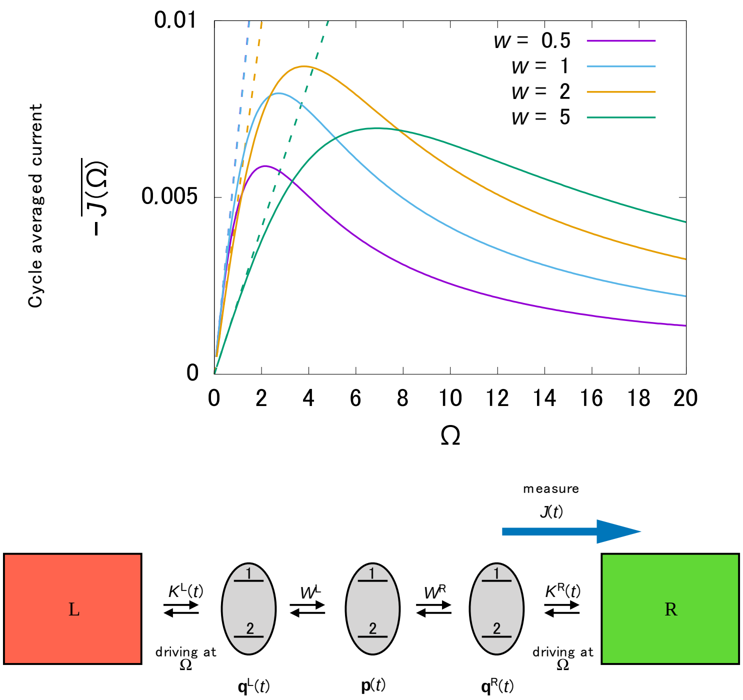

Fig. 1. Schematic of the Markovian system used for the calculations (bottom) and a plot of the modulation speed dependence of the pumping current for selected values of the system parameters (top).

References

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