Summary of thesis : Non-adiabatic effects in quantum geometric pumping

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In this thesis, we clarify the role of non-adiabatic effects in a quantum geometric pumping. A geometric pumping is one of the recent active research subjects, which the pumping current under a periodic modulation of parameters plays an important role. We adopt the method of the general quantum master equation under the Born-Markovian approximation obtained from the weak coupling situation between the target system and the reservoirs with the aid of the full counting statistics. Although the general framework of this thesis is applicable to arbitrary systems if we can assume the quantum Markovian master equation, we often restrict our interest to a spin-boson system for our explicit calculation, where we control the temperatures of two connected reservoirs with the target system. When we sinusoidally control the temperatures of two reservoirs with $\pi/2$ phase difference, we find that the average of a pumping current strongly depends on the initial condition, and thus, the current deviates from that predicted by the adiabatic treatment. We also analytically obtain the contribution of non-adiabatic effects in the pumping current proportional to Ω^3 where Ω is the angular frequency of the temperature control. The validity of the analytic expression is verified by our numerical calculation.

We also derive the fluctuation theorem for a geometric pumping within the framework of the general quantum master equation. The fluctuation theorem which differs from the conventional one leads to the fluctuation dissipation relations as well as nontrivial nonlinear relations. According to the derivation of these relations, we find that the non-adiabatic effects are essential. We partially verify the validity of the fluctuation theorem by the Monte-Carlo simulation for the spin boson system.