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Abstract of Doctoral Thesis

Title: Birth of Quantum Irreversibility and its Lifetime: Case of Quantum Chaos Systems

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It is well known that classically chaotic quantum systems can mimic irreversible behavior characteristic in classical chaos. This fact implies that we can design (or implement) a quantum chaos system even with a few degrees of freedom as a quantum damper which can “thermalize” mechanical work into “heat”, thereby realizing an irreversible energy transportation. Indeed, we propose a Kicked Quantum Damper (KQD) using quantum kicked rotors (QKR or KR) well-known as an ideal model of quantum chaos. We examine computer simulation for it and demonstrate that stationary irreversible energy transportation is achieved in the KQD system, and then the thermal distribution is realized in a degree of freedom of the system. The onset of irreversible energy transport is observed as a phase-transition-like threshold phenomenon, and the entanglement between degrees of freedom composing quantum chaos systems plays a very important role.

Based on the above result, for the purpose of elucidating the relation between quantum irreversibility and entanglement in quantum chaos system, we introduce an indicator to quantify quantum irreversibility: it is the lifetime, in which the quantum chaos system mimics classically irreversible behavior, and a general method to measure it in non-demolition way is proposed. Applying this method to KR (or QKR), statistically clear relation between the lifetime and the quantum entanglement of the degrees of freedoms is observed even at the level of individual eigenstates of the system. Furthermore, it is shown numerically and analytically for the first time that the lifetime of the ideal quantum chaos system is much longer than the time scale known as the Heisenberg time.