[Talk 8] Multi-feedback process with time delay

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We investigate a measurement-feedback process of repeated operations with time delay. During a finite-time interval, measurement on the system is performed and the feedback protocol derived from the measurement outcome is applied with time delay.

Unlike a feedback process without delay, both memories associated with previous and present measurement outcomes are involved in the system dynamics, which naturally brings forth a joint system described by a system state and two memory states. As the feedback protocol depends on memory states sequentially, we can deduce a tighter bound for heat flow by integrating out irrelevant memory states during dynamics.

As a simple example, we consider the so-called cold damping feedback process where the velocity of a particle is measured and a dissipative feedback protocol is applied to decelerate the particle. We confirm that the heat flow is well above the tightest bound. We also examine the long-time limit of this feedback process, which turns out to exhibit an interesting instability transition as well as overshooting by controlling parameters such as measurement errors, time interval, protocol strength, and time delay length. We discuss the underlying mechanism for instability and overshooting, which might be unavoidable in reality.