

## Reversibility, Detailed Balance in Equilibrium and Non-equilibrium Systems

(Tutorial #5)

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We investigate the validity of detailed balance relation in equilibrium and various non-equilibrium conditions. In particular the thermodynamics associated with the reversibility in stochastic trajectories of a probe particle is examined both theoretically and experimentally. Detailed balance condition is explicitly verified for the case of no thermodynamic gradient by direct calculation using the Fokker-Planck equation, and verified experimentally by measuring the forward and reverse transition probabilities for a fluctuating bead trapped by optical tweezers. In the presence of spatial thermodynamic gradient, such as temperature gradient, but under the force balance condition, the reversibility of spatial trajectory of a probe particle is examined and it still obeys a relation similar to detailed balance. For the case of non-equilibrium steady-state with a non-zero particle flux such as diffusion in a tilted periodic potential, the detailed balance condition is also examined.