Dissipated work in nonequilibrium process and relative Fisher information

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Phase space gradient of thermodynamic quantities in a nonequilibrium process and those limitations by information theoretical ones are keys to well understand the system. Dissipation and work are two such quantities in thermodynamic operation between equilibrium states and our present focus.

Any displacement of a system in phase space from a specific equilibrium state to another equilibrium phase point induced by a dynamics has a counterpart process by reversing time. In a previous study, the dissipated work during the process, which is defined as work done on the system minus the associated (equilibrium) free energy difference was one of the chief interests. Therefore, the operational forward and backward movements make us to expect finding a universal relation in the dissipated work in an averaged way. One such intriguing example was focused in [1] and it was shown that the relative entropy in the sense of Kullback-Leibler between the forward and backward equilibrium distributions is equivalent to the dissipated work in the unit of thermal energy.

In this presentation, we provide yet another fundamental relation that holds in the process by focusing on the gradient in the phase space. That is, the relative Fisher information between canonical equilibrium phase densities corresponding to forward and backward processes is intimately related to the gradient of the dissipated work in phase space [2]. Since the Kullback-Leibler relative entropy admits various extensions [3], we can pursue a general relation that links the dissipated work and the notion of distance in statistical mechanics.

We also present a universal constraint on the averaged gradient of the dissipated work via the logarithmic Sobolev inequality [2]. A possible expression of the lower bound indicates a deep connection between the relative entropy and the Fisher information [4] of the canonical distributions.

References

[1] R. Kawai, J.M.R. Parrondo, C. Van den Broeck, Phys. Rev. Lett. 98 (2007) 080602.

[2] T. Yamano, submitted for publication (2012).

[3] T. Yamano, J. Math. Phys. 50 (2009) 043302; T. Yamano, Phys. Lett. A 374 (2010) 3116.

[4] T. Yamano, J. Math. Phys. 53 (2012) 043301.