[Talk 6] Nonequilibrium response in a model for sensory adaptation

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The ability to monitor nutrient and other environmental conditions with high sensitivity is crucial for cell growth and survival. Sensory adaptation allows a cell to recover its sensitivity after a transient response to a shift in the strength of extracellular stimulus. The working principles of adaptation have been established previously based on rate equations which do not consider fluctuations in a thermal environment. Recently, Tu and collaborators (Nature Phys. **8**:422-8, 2012; Phys. Rev. Lett. **115**:118, 2015) performed a detailed analysis of a stochastic model for the E. coli sensory network. They showed that accurate adaptation is possible only when the system operates in a nonequilibrium steady-state. They further obtained a relation among energy dissipation, adaptation speed and adaptation error through model calculation and suggested that it may hold generally. However, adaptation is only one aspect of the bacterial chemo-sensing system. Its transient response to ligand concentration fluctuations with high gain is at least as important. We present here a more refined calculation on the system's response at all frequencies. The simplicity of the model allows a rigorous treatment using methods of statistical mechanics. The model also possesses several desirable analytic properties which make it an attractive testing ground to demystify various general results on energy dissipation and linear response in nonequilibrium states, including for example the link to the Harada-Sasa equality for a discrete-state Markov system[1,2].

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[1] S.-W. Wang, Y. Lan and L.-H. Tang, JSTAT P07025 (2015).
[2] S.-W. Wang, K. Kawaguchi, S.-i. Sasa, and L.-H. Tang, arXiv:1601.04463.