Non-Equilibrium Thermodynamics of Small-Scale Systems

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Concepts of everyday use like energy, heat, and temperature have acquired a precise meaning after the development of thermodynamics. Thermodynamics provides the basis for understanding how heat and work are related and with the general rules that the macroscopic properties of systems at equilibrium follow. Outside equilibrium and away from macroscopic regimes most of those rules cannot be applied directly. We present recent developments that extend the applicability of thermodynamic concepts deep into small-scale and irreversible regimes. We show how the probabilistic interpretation of thermodynamics together with probability conservation laws can be used to obtain kinetic equations for the relevant degrees of freedom. This approach provides a systematic method to obtain the stochastic dynamics of a system directly from its equilibrium properties. A wide variety of situations can be studied in this way, including many that were thought to be out of reach of thermodynamic theories, such as non-linear transport in the presence of potential barriers, activated processes, slow relaxation phenomena, and basic processes in biomolecules, like translocation and stretching.

[1] Vilar, J.M.G.; Rubi, J.M. Proc. Nat. Acad. Sci. **2001**, 98, 11081.
[2] Rubi, J.M.; Bedeaux, D.; Kjelstrup, S. J. Phys. Chem. B **2007,** 111, 9598.
[3] Reguera, D.; Rubi, J.M.; Vilar J.M.G. J. Phys. Chem. B **2005**, 109, 21502; (feature article).
[4] Rubi, J.M.; Scientific American, November, **2008**, 40-45.