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Takahiro Sagawa

Thermodynamics of Information Processing in Small Systems



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Thermodynamics Of Information Processing In Small Systems Springer Theses

**Walter Freeman, Rodrigo Quian
Quiroga**



Thermodynamics Of Information Processing In Small Systems Springer Theses:

Thermodynamics of Information Processing in Small Systems Takahiro Sagawa, 2012-09-14 This thesis presents a general theory of nonequilibrium thermodynamics for information processing Ever since Maxwell's demon was proposed in the nineteenth century the relationship between thermodynamics and information has attracted much attention because it concerns the foundation of the second law of thermodynamics From the modern point of view Maxwell's demon is formulated as an information processing device that performs measurement and feedback at the level of thermal fluctuations By unifying information theory measurement theory and the recently developed theory of nonequilibrium statistical mechanics the author has constructed a theory of information thermodynamics in which information contents and thermodynamic variables are treated on an equal footing In particular the maximum work that can be extracted by the demon and the minimum work that is needed for measurement and information erasure by the demon has been determined Additionally generalizations of nonequilibrium relations such as a Jarzynski equality for classical stochastic systems in the presence of feedback control have been derived One of the generalized equalities has recently been verified experimentally by using sub micron colloidal particles The results obtained serve as fundamental principles for information processing in small thermodynamic systems and are applicable to nanomachines and nanodevices

Crossroad of Maxwell Demon Xavier Bouju, Christian Joachim, 2024-07-22 Written by leading experts in this field this proceedings volume originates from a workshop held in Toulouse on March 1-2, 2023 organized by the ESIM European project Energy Storage Inside Molecules The book explores the intersection and convergence of various perspectives disciplines and research areas related to a modern version of the Maxwell demon at the nanoscale It presents interdisciplinary perspectives on topics such as intramolecular thermodynamics and single molecule motive power and overviews the realm of single objects be it atoms or molecules while also emphasizing on theoretical and experimental approaches with or without the presence of supporting surfaces Notably this comprehensive collection represents the first instance where such intertwined contributions on diverse versions of the Maxwell demon are discussed within the context of the nanoscale It is of great use to graduate students postdoctoral fellows and researchers who are interested in single molecule mechanics

Perspectives on Statistical Thermodynamics Yoshitsugu Oono, 2017-12-14 This original text develops a deep conceptual understanding of thermal physics and highlights the important links between statistical physics and classical thermodynamics It examines how thermal physics fits within physics as a whole and is perfect for undergraduate and graduate students and researchers interested in a fresh approach to the subject

Statistical Mechanics for Athermal Fluctuation Kiyoshi Kanazawa, 2017-11-20 The author investigates athermal fluctuation from the viewpoints of statistical mechanics in this thesis Stochastic methods are theoretically very powerful in describing fluctuation of thermodynamic quantities in small systems on the level of a single trajectory and have been recently developed on the basis of stochastic thermodynamics This thesis proposes for the first time a systematic framework to

describe athermal fluctuation developing stochastic thermodynamics for non Gaussian processes while thermal fluctuations are mainly addressed from the viewpoint of Gaussian stochastic processes in most of the conventional studies First the book provides an elementary introduction to the stochastic processes and stochastic thermodynamics The author derives a Langevin like equation with non Gaussian noise as a minimal stochastic model for athermal systems and its analytical solution by developing systematic expansions is shown as the main result Furthermore the author shows a thermodynamic framework for such non Gaussian fluctuations and studies some thermodynamics phenomena i e heat conduction and energy pumping which shows distinct characteristics from conventional thermodynamics The theory introduced in the book would be a systematic foundation to describe dynamics of athermal fluctuation quantitatively and to analyze their thermodynamic properties on the basis of stochastic methods

Single Molecule Biophysics and Poisson Process Approach to Statistical Mechanics Susanta K Sarkar, 2016-04-01 This is an overview of single molecule physics the study of both equilibrium and non equilibrium properties at the single molecule level It begins with an introduction to this fascinating science and includes a chapter on how to build the most popular instrument for single molecule biophysics the total internal reflection fluorescence TIRF microscope It concludes with the Poisson process approach to statistical mechanics explaining how to relate the process to diverse areas and see how data analysis and error bars are integral parts of science

Mathematical Foundations and Applications of Graph Entropy Matthias Dehmer, Frank Emmert-Streib, Zengqiang Chen, Xueliang Li, Yongtang Shi, 2017-09-12 This latest addition to the successful Network Biology series presents current methods for determining the entropy of networks making it the first to cover the recently established Quantitative Graph Theory An excellent international team of editors and contributors provides an up to date outlook for the field covering a broad range of graph entropy related concepts and methods The topics range from analyzing mathematical properties of methods right up to applying them in real life areas Filling a gap in the contemporary literature this is an invaluable reference for a number of disciplines including mathematicians computer scientists computational biologists and structural chemists

Information Thermodynamics on Causal Networks and its Application to Biochemical Signal Transduction Sosuke Ito, 2016-07-16 In this book the author presents a general formalism of nonequilibrium thermodynamics with complex information flows induced by interactions among multiple fluctuating systems The author has generalized stochastic thermodynamics with information by using a graphical theory Characterizing nonequilibrium dynamics by causal networks he has obtained a novel generalization of the second law of thermodynamics with information that is applicable to quite a broad class of stochastic dynamics such as information transfer between multiple Brownian particles an autonomous biochemical reaction and complex dynamics with a time delayed feedback control This study can produce further progress in the study of Maxwell's demon for special cases As an application to these results information transmission and thermodynamic dissipation in biochemical signal transduction are discussed The findings presented here can open up a novel biophysical approach to understanding information

processing in living systems Experiments on the Thermodynamics of Information Processing Momčilo Gavrilov, 2017-08-01 This thesis reveals how the feedback trap technique developed to trap small objects for biophysical measurement could be adapted for the quantitative study of the thermodynamic properties of small systems The experiments in this thesis are related to Maxwell's demon a hypothetical intelligent neat fingered being that uses information to extract work from heat apparently creating a perpetual motion machine The second law of thermodynamics should make that impossible but how That question has stymied physicists and provoked debate for a century and a half The experiments in this thesis confirm a hypothesis proposed by Rolf Landauer over fifty years ago that Maxwell's demon would need to erase information and that erasing information resetting the measuring device to a standard starting state requires dissipating as much energy as is gained For his thesis work the author used a feedback trap to study the motion of colloidal particles in virtual potentials that may be manipulated arbitrarily The feedback trap confines a freely diffusing particle in liquid by periodically measuring its position and applying an electric field to move it back to the origin Physics, Uspekhi ,1994

Conference Proceedings ,1992 **Computer Books and Serials in Print** ,1985 **Physics Briefs** ,1994

Generalized Thermodynamics Laszlo Tisza,1966 **Paperbound Books in Print** ,1975 Canadian Journal of Fisheries and Aquatic Sciences ,1994 *Acta Physica Polonica* ,1988 Section A includes general physics solid state physics applied physics *Soviet Physics--uspekhi* ,1976 **Journal and Proceedings** Royal Institute of Chemistry,1961

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