Statistical Thermodynamics And Stochastic Theory Of Nonlinear Systems Far From Equilibrium

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CAMILLE PHELPS

Statistical Foundations of Irreversible Thermodynamics Springer Science & Business Media
Some aspects of the physics of many-body systems arbitrarily away from equilibrium, mainly the characterization and irreversible evolution of their macroscopic state, are considered. The present status of phenomenological irreversible thermodynamics is described. An approach for building a statistical thermodynamics - dubbed Informational-Statistical-Thermodynamics - based on a non-equilibrium statistical ensemble formalism is presented. The formalism can be considered as encompassed within the scope of the so-called Predictive Statistical Mechanics, in which the predictability of future states in terms of the knowledge of present and past states, and the question of historicity in the case of systems with complex behaviour, is its main characteristic. The book is recommended for researchers in the area of non-equilibrium statistical mechanics and thermodynamics, as well as a textbook for advanced courses for graduate students in the area of condensed matter physics.
Statistical Thermodynamics Springer
The main theme of the meeting was to illustrate the use of stochastic processes in the study of topological problems in quantum physics and statistical mechanics. Much discussion of current problems was generated and there was a considerable amount of interaction between mathematicians and physicists. The papers presented in the proceedings are essentially of a research nature but some (Lewis, Hudson) are introductions or surveys.
Statistical Mechanics for Athermal Fluctuation Elsevier
A self-contained, mathematical introduction to the driving ideas in equilibrium statistical mechanics, studying important models in detail.
Statistical Mechanics in a Nutshell, Second Edition Princeton University Press
This book presents the fundamentals of stochastic thermodynamics, one of the most central subjects in non-equilibrium statistical mechanics. It also explores many recent advances, e.g., in information thermodynamics, the thermodynamic uncertainty relation, and the trade-off relation between efficiency and power. The content is divided into three main parts, the first of which introduces readers to fundamental topics in stochastic thermodynamics, e.g., the basics of stochastic processes, the fluctuation theorem and its variants, information thermodynamics, and large deviation theory. In turn, parts two and three explore advanced topics such as autonomous engines (engines not controlled externally) and finite speed engines, while also explaining the key concepts from recent stochastic thermodynamics theory that are involved. To fully benefit from the book, readers only need an undergraduate-level background in statistical mechanics and quantum mechanics; no background in information theory or stochastic processes is needed. Accordingly, the book offers a valuable resource for early graduate or higher-level readers who are unfamiliar with this subject but want to keep up with the cutting-edge research in this field. In addition, the author's vivid descriptions interspersed throughout the book will help readers grasp 'living' research developments and begin their own research in this field.
Statistical Mechanics Cambridge University Press
This book encompasses our current understanding of the ensemble approach to many-body physics, phase transitions and other thermal phenomena, as well as the quantum foundations of linear response theory, kinetic equations and stochastic processes. It is destined to be a standard text for graduate students, but it will also serve the specialist-researcher in this fascinating field; some more elementary topics have been included in order to make the book self-contained.The historical methods of J Willard Gibbs and Ludwig Boltzmann, applied to the quantum description rather than phase space, are featured. The tools for computations in the microcanonical, canonical and grand-canonical ensembles are carefully developed and then applied to a variety of classical and standard quantum situations. After the language of second quantization has been introduced, strongly interacting systems, such as quantum liquids, superfluids and superconductivity, are treated in detail. For the connoisseur, there is a section on diagrammatic methods and applications.In the second part dealing with non-equilibrium processes, the emphasis is on the quantum foundations of Markovian behaviour and irreversibility via the Pauli-Van Hove master equation. Justifiable linear response expressions and the quantum-Boltzmann approach are discussed and applied to various condensed matter problems. From this basis the Onsager-Casimir relations are derived, together with the mesoscopic master equation, the Langevin equation and the Fokker-Planck truncation procedure. Brownian motion and modern stochastic problems such as fluctuations in optical signals

and radiation fields briefly make the round.

Statistical Thermodynamics And Stochastic Theory Of Nonequilibrium Systems World Scientific Publishing Company

How can one construct dynamical systems obeying the first and second laws of thermodynamics: mean energy is conserved and entropy increases with time? This book answers the question for classical probability (Part I) and quantum probability (Part II). A novel feature is the introduction of heat particles which supply thermal noise and represent the kinetic energy of the molecules. When applied to chemical reactions, the theory leads to the usual nonlinear reaction-diffusion equations as well as modifications of them. These can exhibit oscillations, or can converge to equilibrium.In this second edition, the text is simplified in parts and the bibliography has been expanded. The main difference is the addition of two new chapters; in the first, classical fluid dynamics is introduced. A lattice model is developed, which in the continuum limit gives us the Euler equations. The five Navier-Stokes equations are also presented, modified by a diffusion term in the continuity equation. The second addition is in the last chapter, which now includes estimation theory, both classical and quantum, using information geometry.

Statistical Thermodynamics of Nonequilibrium Processes Cambridge University Press

This textbook offers an advanced undergraduate or initial graduate level introduction to topics such as kinetic theory, equilibrium statistical mechanics and the theory of fluctuations from a modern perspective. The aim is to provide the reader with the necessary tools of probability theory and thermodynamics (especially the thermodynamic potentials) to enable subsequent study at advanced graduate level. At the same time, the book offers a bird's eye view on arguments that are often disregarded in the main curriculum courses. Further features include a focus on the interdisciplinary nature of the subject and in-depth discussion of alternative interpretations of the concept of entropy. While some familiarity with basic concepts of thermodynamics and probability theory is assumed, this does not extend beyond what is commonly obtained in basic undergraduate curriculum courses.

E. T. Jaynes: Papers on Probability, Statistics and Statistical Physics Springer Science & Business Media

This book presents both the fundamentals and the major research topics in statistical physics of systems out of equilibrium. It summarizes different approaches to describe such systems on the thermodynamic and stochastic levels, and discusses a variety of areas including reactions, anomalous kinetics, and the behavior of self-propelling particles.

Generalized Statistical Thermodynamics Springer Nature

The first six chapters of this volume present the author's 'predictive' or information theoretic' approach to statistical mechanics, in which the basic probability distributions over microstates are obtained as distributions of maximum entropy (Le. , as distributions that are most non-committal with regard to missing information among all those satisfying the macroscopically given constraints). There is then no need to make additional assumptions of ergodicity or metric transitivity; the theory proceeds entirely by inference from macroscopic measurements and the underlying dynamical assumptions. Moreover, the method of maximizing the entropy is completely general and applies, in particular, to irreversible processes as well as to reversible ones. The next three chapters provide a broader framework - at once Bayesian and objective - for maximum entropy inference. The basic principles of inference, including the usual axioms of probability, are seen to rest on nothing more than requirements of consistency, above all, the requirement that in two problems where we have the same information we must assign the same probabilities. Thus, statistical mechanics is viewed as a branch of a general theory of inference, and the latter as an extension of the ordinary logic of consistency. Those who are familiar with the literature of statistics and statistical mechanics will recognize in both of these steps a genuine 'scientific revolution' - a complete reversal of earlier conceptions - and one of no small significance.

Ergodic Theory and Statistical Mechanics World Scientific Publishing Company

The structure of the theory ofthermodynamics has changed enormously since its inception in the middle of the nineteenth century. Shortly after Thomson and Clausius enunciated their versions of the Second Law, Clausius, Maxwell, and Boltzmann began actively pursuing the molecular basis of thermo dynamics, work that culminated in the Boltzmann equation and the theory of transport processes in dilute gases. Much later, Onsager undertook the elucidation of the symmetry oftransport coefficients and, thereby, established himself as the father of the theory of nonequilibrium thermodynamics. Com bining the statistical ideas of Gibbs and Langevin with the phenomenological transport equations, Onsager and others went on to develop a consistent statistical theory of irreversible processes. The power of that theory is in its ability to relate measurable quantities, such as transport coefficients and thermodynamic derivatives, to the results of experimental measurements. As powerful as that theory is, it is linear and limited in validity to a neighborhood of equilibrium. In recent years it has been possible to extend the statistical theory of nonequilibrium processes to include nonlinear effects. The modern theory, as expounded in this book, is applicable to a wide variety of systems both close to and far from equilibrium. The theory is based on the notion of elementary molecular processes, which manifest themselves as random changes in the extensive variables characterizing a system. The theory has a hierarchical character and, thus, can be applied at various levels of molecular detail.

Non-equilibrium Statistical Physics with Application to Disordered Systems Springer

This book develops in detail the statistical foundations of nonequilibrium thermodynamics, based on the mathematical theory of Brownian motion. Author Bernard H. Lavenda demonstrates that thermodynamic criteria emerge in the limit of small thermal fluctuations and in the Gaussian limit where means and modes of the distribution coincide. His treatment assumes the theory of Brownian motion to be a general and practical model of irreversible processes that are inevitably influenced by random thermal fluctuations. This unifying approach permits the extraction of widely applicable principles from the analysis of specific models. Arranged by argument rather than theory, the text is based on the premises that random thermal fluctuations play a decisive role in governing the evolution of nonequilibrium thermodynamic processes and that they can be viewed as a dynamic superposition of many random events. Intended for nonmathematicians working in the areas of nonequilibrium thermodynamics and statistical mechanics, this book will also be of interest to chemical physicists, condensed matter physicists, and readers in the area of nonlinear optics.

Statistical Thermodynamics and Stochastic Kinetics Courier Dover Publications

This unique and consistent mathematical treatise contains a deductive description of equilibrium statistics and thermodynamics. The most important elements of non-equilibrium phenomena are

also treated. In addition to the fundamentals, the text tries to show how large the area of statistical mechanics is and how many applications can be found here. Modern areas such as renormalization group theory, percolation, stochastic equations of motion and their applications in critical dynamics, as well as fundamental thoughts of irreversibility are discussed. The text will be useful for advanced students in physics and other sciences who have profound knowledge of quantum mechanics.
Stochastic Processes in Physics and Chemistry World Scientific
"Statistical Mechanics in a Nutshell offers a concise, self-contained advanced undergraduate to graduate level introduction to this rapidly developing field, requiring a background in elementary calculus and elementary mechanics. It starts with the basics, introduces the most important developments in classical statistical mechanics over the last thirty years, and guides readers to the very threshold of today's cutting-edge research. The author has revised the first 5 chapters (harmonizing the notation, improving the proofs, checking all exercises and adding a few additional interesting ones). He has also added a new chapter on stochastic thermodynamics, which finds its place after the 9th chapter. The appendices will also be completely rewritten, emphasizing the role of convexity and the Jensen inequality. Chapter 8 will be improved to include some important topics: namely, thermostats and fast algorithms. Chapter 9 will also be rewritten to modernize it and to transition to the new chapter on stochastic thermodynamics. Chapter 10 will be split in two, to focus on "disordered systems" and "complex systems," to emphasize applications (including neural networks and optimization algorithms), and to introduce some fundamental techniques (like the cavity method and message passing) at an elementary level. The goal of the new edition is to help the reader find her/his way into and through the vast, recent literature concerning statistical mechanics and to build a sense of the many fields in which the discipline has recently been applied"--
A Farewell to Entropy World Scientific
Presenting the key principles of thermodynamics from a microscopic point of view, this book provides engineers with the knowledge they need to apply thermodynamics and solve engineering challenges at the molecular level. It clearly explains the concepts of entropy and free energy, emphasizing key ideas used in equilibrium applications, whilst stochastic processes, such as stochastic reaction kinetics, are also covered. It provides a classical microscopic interpretation of thermodynamic properties, which is key for engineers, rather than focusing on more esoteric concepts of statistical mechanics and quantum mechanics. Coverage of molecular dynamics and Monte Carlo simulations as natural extensions of the theoretical treatment of statistical thermodynamics is also included, teaching readers how to use computer simulations and thus enabling them to understand and engineer the microcosm. Featuring many worked examples and over 100 end-of-chapter exercises, it is ideal for use in the classroom as well as for self-study.
Stochastic Thermodynamics: An Introduction Springer Science & Business Media
The principal message of this book is that thermodynamics and statistical mechanics will benefit from replacing the unfortunate, misleading and mysterious term ?entropy? with a more familiar, meaningful and appropriate term such as information, missing information or uncertainty. This replacement would facilitate the interpretation of the ?driving force? of many processes in terms of informational changes and dispel the mystery that has always enshrouded entropy.It has been 140 years since Clausius coined the term ?entropy?; almost 50 years since Shannon developed the mathematical theory of ?information? ? subsequently renamed ?entropy.? In this book, the author advocates replacing ?entropy? by ?information,? a term that has become widely used in many branches of science.The author also takes a new and bold approach to thermodynamics and statistical mechanics. Information is used not only as a tool for predicting distributions but as the fundamental cornerstone concept of thermodynamics, held until now by the term ?entropy.? The topics covered include the fundamentals of probability and information theory; the general concept of information as well as the particular concept of information as applied in thermodynamics; the re-derivation of the Sackur?Tetrode equation for the entropy of an ideal gas from purely informational arguments; the fundamental formalism of statistical mechanics; and many examples of simple processes the ?driving force? for which is analyzed in terms of information.
Statistical Mechanics, Kinetic theory, and Stochastic Processes Springer Science & Business Media
These proceedings of the conference Advances in Statistical Mechanics, held in Marseille, France, August 2018, focus on fundamental issues of equilibrium and non-equilibrium dynamics for classical mechanical systems, as well as on open problems in statistical mechanics related to probability, mathematical physics, computer science, and biology. Statistical mechanics, as envisioned more than a century ago by Boltzmann, Maxwell and Gibbs, has recently undergone stunning twists and developments which have turned this old discipline into one of the most active areas of truly interdisciplinary and cutting-edge research. The contributions to this volume, with their rather unique blend of rigorous mathematics and applications, outline the state-of-the-art of this success story in key subject areas of equilibrium and non-equilibrium classical and quantum statistical mechanics of both disordered and non-disordered systems. Aimed at researchers in the broad field of applied modern probability theory, this book, and in particular the review articles, will also be of interest to graduate students looking for a gentle introduction to active topics of current research.
Thermodynamics and Statistical Mechanics of Small Systems Springer
Nobel laureate's brilliant attempt to develop a simple, unified standard method of dealing with all cases of statistical thermodynamics — classical, quantum, Bose-Einstein, Fermi-Dirac, and more.The work also includes discussions of Nernst theorem, Planck's oscillator, fluctuations, the n-particle problem, problem of radiation, and much more.
Stochastic Mechanics and Stochastic Processes Springer Nature
Statistical mechanics attempts to explain the behaviour of macroscopic physical systems in terms of the mechanical properties of their constituents. Although it is one of the fundamental theories of physics, it has received little attention from philosophers of science. Nevertheless, it raises philosophical questions of fundamental importance on the nature of time, chance and reduction. Most philosophical issues in this domain relate to the question of the reduction of thermodynamics to statistical mechanics. This book addresses issues inherent in this reduction: the time-asymmetry of thermodynamics and its absence in statistical mechanics; the role and essential nature of chance and probability in this reduction when thermodynamics is non-probabilistic; and how, if at all, the reduction is possible. Compiling contributions on current research by experts in the field, this is an invaluable survey of the philosophy of statistical mechanics for academic researchers and graduate

students interested in the foundations of physics.

Statistical Thermodynamics and Stochastic Kinetics World Scientific

Statistical Mechanics, Kinetic Theory, and Stochastic Processes presents the statistical aspects of physics as a "living and dynamic" subject. In order to provide an elementary introduction to kinetic theory, physical systems in which particle-particle interaction can be neglected are considered. Transport phenomena in the free-molecular flow region for gases and the transport of thermal radiation are discussed. Discrete random processes such as random walk, binomial and Poisson distributions, and throwing of dice are studied by means of the characteristic function. Comprised of 11 chapters, this book begins with an introduction to the mass point gas as well as some elementary properties of space and velocity distributions. The discussion then turns to radiation and its interaction with an atom; probability, statistics, and conditional probability; intermolecular interactions; transport phenomena; and statistical thermodynamics. Molecular systems at low densities are also considered, together with non-ideal and real gases; liquids and solids; and stochastic processes, noise, and fluctuations. In particular, the response of atoms and molecules to perturbations and scattering by crystals, liquids, and high-pressure gases are examined. This monograph will be useful for undergraduate students, practitioners, and researchers in physics.

Nonequilibrium Statistical Physics of Small Systems MDPI

"Presenting the key principles of thermodynamics from a microscopic point of view, this book provides engineers with the knowledge they need to apply thermodynamics and solve engineering challenges at the molecular level. It clearly explains the concerns of entropy and free energy, emphasising key concepts used in equilibrium applications, whilst stochastic processes, such as stochastic reaction kinetics, are also covered. It provides a classical microscopic interpretation of thermodynamic concepts which is key for engineers, rather than focusing on more esoteric concepts of statistical thermodynamics and quantum mechanics. Coverage of molecular dynamics and Monte Carlo simulations as natural extensions of the theoretical treatment of statistical thermodynamics is also included, teaching readers how to use computer simulations and thus enabling them to understand and engineer the microcosm. Featuring many worked examples and over 100 end-of-chapter exercises, it is ideal for use in the classroom as well as for self-study"--