

Thermomechanics Of Phase Transitions In Classical Field Theory

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Explore the intricate interplay of thermomechanics and phase transitions within the framework of classical field theory. This domain investigates how fundamental physical laws, expressed through classical fields, govern the macroscopic changes in a system's state, encompassing concepts from thermodynamics and leading to an understanding of critical phenomena at various scales. It delves into the energy, forces, and dynamics that drive these transformative processes without recourse to quantum mechanics.

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Thermomechanics Of Phase Transitions In Classical Field Theory

The complex processes of state changes can be interpreted by resorting to Statistical Quantum Mechanics. However, it is well known that a phenomenological description of state changes can be obtained by using the classical continuum theory. This book supplies a panoramic picture of known and new mathematical models which are suitable to describe phase changes from a macroscopic view point. All these models are derived from the theory of continuous systems with a nonmaterial interface and allow to describe processes of solidification, melting, and vaporization. The nonlocal continuum theory of systems with a non material interface provides a more complex mathematical model in dealing with crystal growth either in a pure melt or in a mixture. A chapter is devoted to the analysis of phase changes in ferroelectric and ferromagnetic crystals.

Statistical Mechanics of Phase Transitions

The book provides an introduction to the physics which underlies phase transitions and to the theoretical techniques currently at our disposal for understanding them. It will be useful for advanced undergraduates, for post-graduate students undertaking research in related fields, and for established researchers in experimental physics, chemistry, and metallurgy as an exposition of current theoretical understanding. - ;Recent developments have led to a good understanding of universality; why phase transitions in systems as diverse as magnets, fluids, liquid crystals, and superconductors can be brought under the same theoretical umbrella and well described by simple models. This book describes the physics underlying universality and then lays out the theoretical approaches now available for studying phase transitions. Traditional techniques, mean-field theory, series expansions, and the

transfer matrix, are described; the Monte Carlo method is covered, and two chapters are devoted to the renormalization group, which led to a break-through in the field. The book will be useful as a textbook for a course in 'Phase Transitions', as an introduction for graduate students undertaking research in related fields, and as an overview for scientists in other disciplines who work with phase transitions but who are not aware of the current tools in the armoury of the theoretical physicist. - ;Introduction; Statistical mechanics and thermodynamics; Models; Mean-field theories; The transfer matrix; Series expansions; Monte Carlo simulations; The renormalization group; Implementations of the renormalization group. -

Field Theoretic Method in Phase Transformations

This book describes a novel and popular method for the theoretical and computational study of phase transformations and materials processing in condensed and soft matter. The field theoretic method for the study of phase transformations in material systems, also known as the phase-field method, allows one to analyze different stages of transformations within a unified framework. It has received significant attention in the materials science community due to many recent successes in solving or illuminating important problems. In a single volume, this book addresses the fundamentals of the method starting from the basics of the field theoretic method along with its most important theoretical and computational results and some of the most advanced recent results and applications. Now in a revised and expanded second edition, the text is updated throughout and includes material on the classical theory of phase transformations. This book serves as both a primer in the area of phase transformations for those new to the field and as a guide for the more seasoned researcher. It is also of interest to historians of physics.

Introduction to the Theory of Critical Phenomena

This book provides a comprehensive introduction to the theory of phase transitions and critical phenomena. The content covers a period of more than 100 years of theoretical research of condensed matter phases and phase transitions providing a clear interrelationship with experimental problems. It starts from certain basic University knowledge of thermodynamics, statistical physics and quantum mechanics. The text is illustrated with classic examples of phase transitions. Various types of phase transition and (multi)critical points are introduced and explained. The classic aspects of the theory are naturally related with the modern developments. This interrelationship and the field-theoretical renormalization group method are presented in details. The main applications of the renormalization group methods are presented. Special attention is paid to the description of quantum phase transitions. This edition contains a more detailed presentation of the renormalization group method and its applications to particular systems.

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Thermal Quantum Field Theory

This monograph presents recent developments in quantum field theory at finite temperature. By using Lie groups, ideas from thermal theory are considered with concepts of symmetry, allowing for applications not only to quantum field theory but also to transport theory, quantum optics and statistical mechanics. This includes an analysis of geometrical and topological aspects of spatially confined systems with applications to the Casimir effect, superconductivity and phase transitions. Finally, some developments in open systems are also considered. The book provides a unified picture of the fundamental aspects in thermal quantum field theory and their applications, and is important to the field as a result, since it combines several diverse ideas that lead to a better understanding of different areas of physics.

Applications Of Field Theory Methods In Statistical Physics Of Nonequilibrium Systems

This book formulates a unified approach to the description of many-particle systems combining the methods of statistical physics and quantum field theory. The benefits of such an approach are in the description of phase transitions during the formation of new spatially inhomogeneous phases, as well in describing quasi-equilibrium systems with spatially inhomogeneous particle distributions (for example, self-gravitating systems) and metastable states. The validity of the methods used in the statistical description of many-particle systems and models (theory of phase transitions included) is discussed and compared. The idea of using the quantum field theory approach and related topics (path integration, saddle-point and stationary-phase methods, Hubbard-Stratonovich transformation, mean-field theory, and functional integrals) is described in detail to facilitate further understanding and explore more applications. To some extent, the book could be treated as a brief encyclopedia of methods applicable to the statistical description of spatially inhomogeneous equilibrium and metastable particle distributions. Additionally, the general approach is not only formulated, but also applied to solve various practically important problems (gravitating gas, Coulomb-like systems, dusty plasmas, thermodynamics of cellular structures, non-uniform dynamics of gravitating systems, etc.).

Thermal Quantum Field Theory

First published in 1971, this highly popular text is devoted to the interdisciplinary area of critical phenomena, with an emphasis on liquid-gas and ferromagnetic transitions. Advanced undergraduate and graduate students in thermodynamics, statistical mechanics, and solid state physics, as well as researchers in physics, mathematics, chemistry, and materials science, will welcome this paperback edition of Stanley's acclaimed text.

Introduction to Phase Transitions and Critical Phenomena

In these lectures we summarize certain results on models in statistical physics and quantum field theory and especially emphasize the deep relationship between these subjects. From a physical point of view, we study phase transitions of realistic systems; from a more mathematical point of view, we describe field theoretical models defined on a euclidean space-time lattice, for which the lattice constant serves as a cutoff. The connection between these two approaches is obtained by identifying partition functions for spin models with discretized functional integrals. After an introduction to critical phenomena, we present methods which prove the existence or nonexistence of phase transitions for the Ising and Heisenberg models in various dimensions. As an example of a solvable system we discuss the two-dimensional Ising model. Topological excitations determine sectors of field theoretical models. In order to illustrate this, we first discuss soliton solutions of completely integrable classical models. Afterwards we discuss sectors for the external field problem and for the Schwinger model. Then we put gauge models on a lattice, give a survey of some rigorous results and discuss the phase structure of some lattice gauge models. Since great interest has recently been shown in string models, we give a short introduction to both the classical mechanics of strings and the bosonic and fermionic models. The formulation of the continuum limit for lattice systems leads to a discussion of the renormalization group, which we apply to various models.

Models in Statistical Physics and Quantum Field Theory

This monograph develops a unified microscopic basis for phases and phase changes of bulk matter and small systems, based on classical physics. It describes the thermodynamics of ensembles of particles and explains phase transition in gaseous and liquid systems. The origins are derived from

simple but physically relevant models of how transitions occur between rigid and fluid states, of how phase equilibria arise, and how they differ for small and large systems.

Phase Transitions of Simple Systems

This is a textbook which gradually introduces the student to the statistical mechanical study of the different phases of matter and to the phase transitions between them. Throughout, only simple models of both ordinary and soft matter are used but these are studied in full detail. The subject is developed in a pedagogical manner, starting from the basics, going from the simple ideal systems to the interacting systems, and ending with the more modern topics. The textbook provides the student with a complete overview, intentionally at an introductory level, of the theory of phase transitions. All equations and deductions are included.

Equilibrium Statistical Physics

Provides a critical elaboration of thermodynamics as applied to phase transition, discusses the relationship between the ensemble theory of classical and quantum statistics and thermodynamics, and then obtains Maxwell-Boltzmann, Fermi-Dirac and the Bose-Einstein distributions.

Thermodynamics and Statistical Mechanics

Theory of Phase Transitions: Rigorous Results is inspired by lectures on mathematical problems of statistical physics presented in the Mathematical Institute of the Hungarian Academy of Sciences, Budapest. The aim of the book is to expound a series of rigorous results about the theory of phase transitions. The book consists of four chapters, wherein the first chapter discusses the Hamiltonian, its symmetry group, and the limit Gibbs distributions corresponding to a given Hamiltonian. The second chapter studies the phase diagrams of lattice models that are considered at low temperatures. The notions of a ground state of a Hamiltonian and the stability of the set of the ground states of a Hamiltonian are also introduced. Chapter 3 presents the basic theorems about lattice models with continuous symmetry, and Chapter 4 focuses on the second-order phase transitions and on the theory of scaling probability distributions, connected to these phase transitions. Specialists in statistical physics and other related fields will greatly benefit from this publication.

Theory of Phase Transitions

The understanding of phase transitions has long been a fundamental problem of statistical mechanics. It has made spectacular progress during the last few years, largely because of the ideas of K.G. Wilson, in applying to an apparently quite different domain the methods of the renormalization group, which had been developed in the framework of the quantum theory of fields. The ability of these theoretical methods to lead to very precise predictions has, in turn, stimulated in the last few years more refined experiments in different areas. We now have entered a period where the theoretical results yielded by the renormalization group approach are sufficiently precise and can be compared with those of the traditional method of high temperature series expansion on lattices, and with the experimental data. Although very similar, the results coming from the renormalization group and high temperature analysis seemed to indicate systematic discrepancies between the continuous field theory and lattice models. It was therefore important to appreciate the reliability of the predictions coming from both theoretical schemes, and to compare them to the latest experimental results. We think that this Cargèse Summer Institute has been very successful in this respect. Indeed, leading experts in the field, both experimentalists and theoreticians, have gathered and presented detailed analysis of the present situation. In particular, B.G. Nickel has produced longer high temperature series which seem to indicate that the discrepancies between series and renormalization group results have been previously overestimated.

Phase Transitions Cargèse 1980

This 2006 work began with the author's exploration of the applicability of the finite deformation theory of elasticity when various standard assumptions such as convexity of various energies or ellipticity of the field equations of equilibrium are relinquished. The finite deformation theory of elasticity turns out to be a natural vehicle for the study of phase transitions in solids where thermal effects can be neglected. This text will be of interest to those interested in the development and application of continuum-mechanical models that describe the macroscopic response of materials capable of undergoing stress-

or temperature-induced transitions between two solid phases. The focus is on the evolution of phase transitions which may be either dynamic or quasi-static, controlled by a kinetic relation which in the framework of classical thermomechanics represents information that is supplementary to the usual balance principles and constitutive laws of conventional theory.

Evolution of Phase Transitions

... "What do you call work?" "Why ain't that work?" Tom resumed his whitewashing, and answered carelessly: "Well. It is, and maybe it ain't. All I know, is, it suits Tom Sawyer." "Oil CO/III!, IOW, Will do not mean to let 011 that you like it?" The brush continued to move. "Like it? Well, I do not see why I oughtn't to like it. Does a boy get a chance to whitewash a fence every day?" That put the thing all a new light. Ben stopped nibbling the apple ... (From Mark Twain's Adventures of Tom Sawyer, Chapter II.) Mathematics can put quantitative phenomena in a new light; in turn applications may provide a vivid support for mathematical concepts. This volume illustrates some aspects of the mathematical treatment of phase transitions, namely, the classical Stefan problem and its generalizations. The intended reader is a researcher in application-oriented mathematics. An effort has been made to make a part of the book accessible to beginners, as well as physicists and engineers with a mathematical background. Some room has also been devoted to illustrate analytical tools. This volume deals with research I initiated when I was affiliated with the Istituto di Analisi Numerica del C.N.R. in Pavia, and then continued at the Dipartimento di Matematica dell'Universita di Trento. It was typeset by the author in plain TEX

Models of Phase Transitions

This book covers the foundations of classical thermodynamics, with emphasis on the use of differential forms of classical and quantum statistical mechanics, and also on the foundational aspects. In both contexts, a number of applications are considered in detail, such as the general theory of response, correlations and fluctuations, and classical and quantum spin systems. In the quantum case, a self-contained introduction to path integral methods is given. In addition, the book discusses phase transitions and critical phenomena, with applications to the Landau theory and to the Ginzburg–Landau theory of superconductivity, and also to the phenomenon of Bose condensation and of superfluidity. Finally, there is a careful discussion on the use of the renormalization group in the study of critical phenomena. Request Inspection Copy

Statistical Mechanics

Phase transition phenomena arise in a variety of relevant real world situations, such as melting and freezing in a solid-liquid system, evaporation, solid-solid phase transitions in shape memory alloys, combustion, crystal growth, damage in elastic materials, glass formation, phase transitions in polymers, and plasticity. The practical interest of such phenomenology is evident and has deeply influenced the technological development of our society, stimulating intense mathematical research in this area. This book analyzes and approximates some models and related partial differential equation problems that involve phase transitions in different contexts and include dissipation effects. Contents: Mathematical Models Including a Hysteresis Operator (T Aiki); Modelling Phase Transitions via an Entropy Equation: Long-Time Behavior of the Solutions (E Bonetti); Global Solution to a One Dimensional Phase Transition Model with Strong Dissipation (G Bonfanti & F Luterotti); A Global in Time Result for an Integro-Differential Parabolic Inverse Problem in the Space of Bounded Functions (F Colombo et al.); Weak Solutions for Stefan Problems with Convections (T Fukao); Memory Relaxation of the One-Dimensional Cahn-Hilliard Equation (S Gatti et al.); Mathematical Models for Phase Transition in Materials with Thermal Memory (G Gentili & C Giorgi); Hysteresis in a First Order Hyperbolic Equation (J Kopfovi); Approximation of Inverse Problems Related to Parabolic Integro-Differential Systems of Caginalp Type (A Lorenzi & E Rocca); Gradient Flow Reaction/Diffusion Models in Phase Transitions (J Norbury & C Girardet); New Existence Result for a 3-D Shape Memory Model (I Pawlow & W M Zajackowski); Analysis of a 1-D Thermoviscoelastic Model with Temperature-Dependent Viscosity (R Peyroux & U Stefanelli); Global Attractor for the Weak Solutions of a Class of Viscous Cahn-Hilliard Equations (R Rossi); Stability for Phase Field Systems Involving Indefinite Surface Tension Coefficients (K Shirakawa); Geometric Features of p -Laplace Phase Transitions (E Valdinoci). Readership: Applied mathematicians and researchers in analysis and differential equations."

Dissipative Phase Transitions

The Physics of Phase Transitions occupies an important place at the crossroads of several fields central to materials sciences. This second edition incorporates new developments in the states of matter physics, in particular in the domain of nanomaterials and atomic Bose-Einstein condensates where progress is accelerating. New information and application examples are included. This work deals with all classes of phase transitions in fluids and solids, containing chapters on evaporation, melting, solidification, magnetic transitions, critical phenomena, superconductivity, and more. End-of-chapter problems and complete answers are included.

The Physics of Phase Transitions

Nucleation is the initial step of every first-order phase transition, and most phase transitions encountered both in everyday life and industrial processes are of the first-order. Using an elegant classical theory based on thermodynamics and kinetics, this book provides a fully detailed picture of multi-component nucleation. As many of the issues concerning multi-component nucleation theory have been solved during the last 10-15 years, it also thoroughly integrates both fundamental theory with recent advances presented in the literature. Classical Nucleation Theory in Multicomponent Systems serves as a textbook for advanced thermodynamics courses, as well as an important reference for researchers in the field. The main topics covered are: the basic relevant thermodynamics and statistical physics; modelling a molecular cluster as a spherical liquid droplet; predicting the size and composition of the nucleating critical clusters; kinetic models for cluster growth and decay; calculating nucleation rates; and a full derivation and application of nucleation theorems that can be used to extract microscopic cluster properties from nucleation rate measurements. The assumptions and approximations needed to build the classical theory are described in detail, and the reasons why the theory fails in certain cases are explained. Relevant problems are presented at the end of each chapter.

Classical Nucleation Theory in Multicomponent Systems

Newer Edition Available: Equilibrium Statistical Physics (3rd Edition) This revised and expanded edition of one of the important textbook in statistical physics, is a graduate level text suitable for students in physics, chemistry, and materials science. After a short review of basic concepts, the authors begin the discussion on strongly interacting condensed matter systems with a thorough treatment of mean field and Landau theories of phase transitions. Many examples are worked out in considerable detail. Classical liquids are treated next. Along with traditional approaches to the subject such as the virial expansion and integral equations, newer theories such as perturbation theory and density functional theories are introduced. The modern theory of phase transitions occupies a central place in this book. The development is along historical lines, beginning with the Onsager solution of the two-dimensional Ising model, series expansions, scaling theory, finite-size scaling, and the universality hypothesis. A separate chapter is devoted to the renormalization group approach to critical phenomena. The development of the basic tools is completed in a new chapter on computer simulations in which both Monte Carlo and molecular dynamics techniques are introduced. The remainder of the book is concerned with a discussion of some of the more important modern problems in condensed matter theory. A chapter on quantum fluids deals with Bose condensation, superfluidity, and the BCS and Landau-Ginzburg theories of superconductivity. A new chapter on polymers and membranes contains a discussion of the Gaussian and Flory models of dilute polymer mixtures, the connection of polymer theory to critical phenomena, a discussion of dense polymer mixtures and an introduction to the physical properties of solid and fluid membranes. A chapter on linear response includes the Kubo formalism, the fluctuation-dissipation theorem, Onsager relations and the Boltzmann equation. The last chapter is devoted to disordered materials. Each chapter contains a substantial number of exercises. A manual with a complete set of solutions to these problems is available under separate cover.

Equilibrium Statistical Physics (2nd Edition)

Most interesting and difficult problems in equilibrium statistical mechanics concern models which exhibit phase transitions. For graduate students and more experienced researchers this book provides an invaluable reference source of approximate and exact solutions for a comprehensive range of such models. Part I contains background material on classical thermodynamics and statistical mechanics, together with a classification and survey of lattice models. The geometry of phase transitions is described and scaling theory is used to introduce critical exponents and scaling laws. An introduction is given to finite-size scaling, conformal invariance and Schramm—Loewner evolution. Part II contains accounts of classical mean-field methods. The parallels between Landau expansions and catastrophe

theory are discussed and Ginzburg--Landau theory is introduced. The extension of mean-field theory to higher-orders is explored using the Kikuchi--Hijmans--De Boer hierarchy of approximations. In Part III the use of algebraic, transformation and decoration methods to obtain exact system information is considered. This is followed by an account of the use of transfer matrices for the location of incipient phase transitions in one-dimensionally infinite models and for exact solutions for two-dimensionally infinite systems. The latter is applied to a general analysis of eight-vertex models yielding as special cases the two-dimensional Ising model and the six-vertex model. The treatment of exact results ends with a discussion of dimer models. In Part IV series methods and real-space renormalization group transformations are discussed. The use of the De Neef--Enting finite-lattice method is described in detail and applied to the derivation of series for a number of model systems, in particular for the Potts model. The use of Padé, differential and algebraic approximants to locate and analyze second- and first-order transitions is described. The realization of the ideas of scaling theory by the renormalization group is presented together with treatments of various approximation schemes including phenomenological renormalization. Part V of the book contains a collection of mathematical appendices intended to minimise the need to refer to other mathematical sources.

Equilibrium Statistical Mechanics of Lattice Models

This book summarizes results on the creation of a new theory of condensation which has an impact on consideration of some microscopic effects left aside in the usual nucleation theories. In particular, the main idea of the authors' microscopic condensation theory is that it considers the violation of the equilibrium cluster distribution over the internal degrees of freedom due to co-occurring condensation and decay reactions of the clusters. Contents: Brief Review of the Existing Nucleation Theories Main Principles of the Microscopic Theory of Condensation Juxtaposition with the Other Theories and Experiments Kinetic Theory of Photostimulated Nucleation Kinetic Theory of Iron-Induced Nucleation- Conclusions Appendices: Dimensionless Form of System Low-Pressure Limit Quasisteady Equations for Concentrations FORTRAN Subroutines for Computing Parameters of the Theory Readership: Applied mathematicians, physicists, chemists and aeronomers. keywords: Nucleation; Nonequilibrium; Kinetics; Internal Degrees of Freedom; Cluster; Ion-Induced; Photo-Stimulated; Diffusion Chamber; Analytical Solutions; New Rate Constants; Fortran Subroutines

Microscopic Theory of Condensation in Gases and Plasma

This short textbook covers roughly 13 weeks of lectures on advanced statistical mechanics at the graduate level. It starts with an elementary introduction to the theory of ensembles from classical mechanics, and then goes on to quantum statistical mechanics with density matrix. These topics are covered concisely and briefly. The advanced topics cover the mean-field theory for phase transitions, the Ising models and their exact solutions, and critical phenomena and their scaling theory. The mean-field theories are discussed thoroughly with several different perspectives — focusing on a single degree, or using Feynman-Jensen-Bogoliubov inequality, cavity method, or Landau theory. The renormalization group theory is mentioned only briefly. As examples of computational and numerical approach, there is a chapter on Monte Carlo method including the cluster algorithms. The second half of the book studies nonequilibrium statistical mechanics, which includes the Brownian motion, the Langevin and Fokker-Planck equations, Boltzmann equation, linear response theory, and the Jarzynski equality. The book ends with a brief discussion of irreversibility. The topics are supplemented by problem sets (with partial answers) and supplementary readings up to the current research, such as heat transport with a Fokker-Planck approach.

Advanced Statistical Mechanics

This textbook covers the basic principles of statistical physics and thermodynamics. The text is pitched at the level equivalent to first-year graduate studies or advanced undergraduate studies. It presents the subject in a straightforward and lively manner. After reviewing the basic probability theory of classical thermodynamics, the author addresses the standard topics of statistical physics. The text demonstrates their relevance in other scientific fields using clear and explicit examples. Later chapters introduce phase transitions, critical phenomena and non-equilibrium phenomena.

Introduction to Statistical Physics

Thermodynamics is a well-established discipline of physics for properties of matter in thermal equilibrium with the surroundings. Applying to crystals, however, the laws encounter undefined properties

of crystal lattice, which therefore need to be determined for a clear and well-defined description of crystalline states. *Thermodynamics of Crystalline States* explores the roles played by order variables and dynamic lattices in crystals in a wholly new way. The book begins by clarifying basic concepts for stable crystals. Next, binary phase transitions are discussed to study collective motion of order variables, as described mostly as classical phenomena. New to this edition is the examination of magnetic crystals, where magnetic symmetry is essential for magnetic phase transitions. The multi-electron system is also discussed theoretically, as a quantum-mechanical example, for superconductivity in metallic crystals. Throughout the book, the role played by the lattice is emphasized and studied in-depth. *Thermodynamics of Crystalline States* is an introductory treatise and textbook on mesoscopic phenomena in solid states, constituting a basic subject in condensed matter physics. While this book serves as a guide for advanced students in physics and material science, it can also be useful as a reference for all professionals in related fields. Minoru Fujimoto is author of *Physics of Classical Electromagnetism* (Springer, 2007) and *The Physics of Structural Phase Transitions* (Springer, 2005).

Thermodynamics of Crystalline States

While most introductions to statistical mechanics are either too mathematical or too physical, Colin Thompson's book combines mathematical rigor with familiar physical materials. Following introductory chapters on kinetic theory, thermodynamics, the Gibbs ensembles, and the thermodynamic limit, later chapters discuss the classical theories of phase transitions, the Ising model, algebraic methods and combinatorial methods for solving the two-dimensional model in zero field, and some applications of the Ising model to biology. Originally published in 1979. The Princeton Legacy Library uses the latest print-on-demand technology to again make available previously out-of-print books from the distinguished backlist of Princeton University Press. These editions preserve the original texts of these important books while presenting them in durable paperback and hardcover editions. The goal of the Princeton Legacy Library is to vastly increase access to the rich scholarly heritage found in the thousands of books published by Princeton University Press since its founding in 1905.

Mathematical Statistical Mechanics

This textbook covers the basic principles of statistical physics and thermodynamics. The text is pitched at the level equivalent to first-year graduate studies or advanced undergraduate studies. It presents the subject in a straightforward and lively manner. After reviewing the basic probability theory of classical thermodynamics, the author addresses the standard topics of statistical physics. The text demonstrates their relevance in other scientific fields using clear and explicit examples. Later chapters introduce phase transitions, critical phenomena and non-equilibrium phenomena.

Introduction to Statistical Physics

This book of lecture notes contains theoretical background material required for computer generation of random fields, which is of interest in various fields of applied mathematics. The necessary probabilistic background suitable for applied work in engineering as well as signal and image processing is also covered. The book is a valuable guide for higher level engineering students.

Lectures on Probability and Second Order Random Fields

Building on the material learned by students in their first few years of study, *Topics in Statistical Mechanics (Second Edition)* presents an advanced level course on statistical and thermal physics. It begins with a review of the formal structure of statistical mechanics and thermodynamics considered from a unified viewpoint. There is a brief revision of non-interacting systems, including quantum gases and a discussion of negative temperatures. Following this, emphasis is on interacting systems. First, weakly interacting systems are considered, where the interest is in seeing how small interactions cause small deviations from the non-interacting case. Second, systems are examined where interactions lead to drastic changes, namely phase transitions. A number of specific examples is given, and these are unified within the Landau theory of phase transitions. The final chapter of the book looks at non-equilibrium systems, in particular the way they evolve towards equilibrium. This is framed within the context of linear response theory. Here fluctuations play a vital role, as is formalised in the fluctuation-dissipation theorem. The second edition has been revised particularly to help students use this book for self-study. In addition, the section on non-ideal gases has been expanded, with a treatment of the hard-sphere gas, and an accessible discussion of interacting quantum gases. In many cases

there are details of Mathematica calculations, including Mathematica Notebooks, and expression of some results in terms of Special Functions.

Topics In Statistical Mechanics (Second Edition)

Boltzmann's formula $S = \ln(W(E))$ defines the microcanonical ensemble. The usual textbooks on statistical mechanics start with the microensemble but rather quickly switch to the canonical ensemble introduced by Gibbs. This has the main advantage of easier analytical calculations, but there is a price to pay -- for example, phase transitions can only be defined in the thermodynamic limit of infinite system size. The question how phase transitions show up from systems with, say, 100 particles with an increasing number towards the bulk can only be answered when one finds a way to define and classify phase transitions in small systems. This is all possible within Boltzmann's original definition of the microcanonical ensemble. Starting from Boltzmann's formula, the book formulates the microcanonical thermodynamics entirely within the frame of mechanics. This way the thermodynamic limit is avoided and the formalism applies to small as well to other nonextensive systems like gravitational ones. Phasetransitions of first order, continuous transitions, critical lines and multicritical points can be unambiguously defined by the curvature of the entropy $S(E, N)$. Special attention is given to the fragmentation of nuclei and atomic clusters as a peculiar phase transition of small systems controlled, among others, by angular momentum. The dependence of the liquid-gas transition of small atomic clusters under prescribed pressure is treated. Thus the analogue to the bulk transition can be studied. New insights into the many facets of the many-body physics of the critical point are presented. The book also describes the microcanonical statistics of the collapse of a self-gravitating system under large angular momentum.

Microcanonical Thermodynamics

Summaries in French, German, and Russian.

Thermodynamics of Finite Systems and the Kinetics of First-Order Phase Transitions

'This is an excellent book from which to learn the methods and results of statistical mechanics.' Nature 'A well written graduate-level text for scientists and engineers... Highly recommended for graduate-level libraries.' Choice This highly successful text, which first appeared in the year 1972 and has continued to be popular ever since, has now been brought up-to-date by incorporating the remarkable developments in the field of 'phase transitions and critical phenomena' that took place over the intervening years. This has been done by adding three new chapters (comprising over 150 pages and containing over 60 homework problems) which should enhance the usefulness of the book for both students and instructors. We trust that this classic text, which has been widely acclaimed for its clean derivations and clear explanations, will continue to provide further generations of students a sound training in the methods of statistical physics.

Statistical Mechanics

Scheck's textbook starts with a concise introduction to classical thermodynamics, including geometrical aspects. Then a short introduction to probabilities and statistics lays the basis for the statistical interpretation of thermodynamics. Phase transitions, discrete models and the stability of matter are explained in great detail. Thermodynamics has a special role in theoretical physics. Due to the general approach of thermodynamics the field has as a bridging function between several areas like the theory of condensed matter, elementary particle physics, astrophysics and cosmology. The classical thermodynamics describes predominantly averaged properties of matter, reaching from few particle systems and state of matter to stellar objects. Statistical Thermodynamics covers the same fields, but explores them in greater depth and unifies classical statistical mechanics with quantum theory of multiple particle systems. The content is presented as two tracks: the fast track for master students, providing the essentials, and the intensive track for all wanting to get in depth knowledge of the field. Clearly labelled material and sections guide students through the preferred level of treatment. Numerous problems and worked examples will provide successful access to Statistical Physics and Thermodynamics.

Statistical Theory of Heat

In Statistical Physics one of the ambitious goals is to derive rigorously, from statistical mechanics, the thermodynamic properties of models with realistic forces. Elliott Lieb is a mathematical physicist who meets the challenge of statistical mechanics head on, taking nothing for granted and not being content until the purported consequences have been shown, by rigorous analysis, to follow from the premises. The present volume contains a selection of his contributions to the field, in particular papers dealing with general properties of Coulomb systems, phase transitions in systems with a continuous symmetry, lattice crystals, and entropy inequalities. It also includes work on classical thermodynamics, a discipline that, despite many claims to the contrary, is logically independent of statistical mechanics and deserves a rigorous and unambiguous foundation of its own. The articles in this volume have been carefully annotated by the editors.

Statistical Mechanics

This book presents thermal field theory techniques, which can be applied in both cosmology and the theoretical description of the QCD plasma generated in heavy-ion collision experiments. It focuses on gauge interactions (whether weak or strong), which are essential in both contexts. As well as the many differences in the physics questions posed and in the microscopic forces playing a central role, the authors also explain the similarities and the techniques, such as the resummations, that are needed for developing a formally consistent perturbative expansion. The formalism is developed step by step, starting from quantum mechanics; introducing scalar, fermionic and gauge fields; describing the issues of infrared divergences; resummations and effective field theories; and incorporating systems with finite chemical potentials. With this machinery in place, the important class of real-time (dynamic) observables is treated in some detail. This is followed by an overview of a number of applications, ranging from the study of phase transitions and particle production rate computations, to the concept of transport and damping coefficients that play a ubiquitous role in current developments. The book serves as a self-contained textbook on relativistic thermal field theory for undergraduate and graduate students of theoretical high-energy physics.

Basics of Thermal Field Theory

This book offers a broad overview of the potential of continuum mechanics to describe a wide range of macroscopic phenomena in real-world problems. Building on the fundamentals presented in the authors' previous book, *Continuum Mechanics using Mathematica®*, this new work explores interesting models of continuum mechanics, with an emphasis on exploring the flexibility of their applications in a wide variety of fields.

Continuum Mechanics

A brand-new conceptual look at dynamical thermodynamics This book merges the two universalisms of thermodynamics and dynamical systems theory in a single compendium, with the latter providing an ideal language for the former, to develop a new and unique framework for dynamical thermodynamics. In particular, the book uses system-theoretic ideas to bring coherence, clarity, and precision to an important and poorly understood classical area of science. The dynamical systems formalism captures all of the key aspects of thermodynamics, including its fundamental laws, while providing a mathematically rigorous formulation for thermodynamical systems out of equilibrium by unifying the theory of mechanics with that of classical thermodynamics. This book includes topics on nonequilibrium irreversible thermodynamics, Boltzmann thermodynamics, mass-action kinetics and chemical reactions, finite-time thermodynamics, thermodynamic critical phenomena with continuous and discontinuous phase transitions, information theory, continuum and stochastic thermodynamics, and relativistic thermodynamics. A Dynamical Systems Theory of Thermodynamics develops a postmodern theory of thermodynamics as part of mathematical dynamical systems theory. The book establishes a clear nexus between thermodynamic irreversibility, the second law of thermodynamics, and the arrow of time to further unify discreteness and continuity, indeterminism and determinism, and quantum mechanics and general relativity in the pursuit of understanding the most fundamental property of the universe—the entropic arrow of time.

A Dynamical Systems Theory of Thermodynamics

This popular, often cited text returns in a softcover edition to provide a thorough introduction to statistical physics and thermodynamics, and to exhibit the universal chain of ideas leading from the laws of microphysics to the macroscopic behaviour of matter. A wide range of applications illustrates

the concepts, and many exercises reinforce understanding. Volume II applies statistical methods to systems governed by quantum effects, in particular to solid state physics, explaining properties due to the crystal structure or to the lattice excitations or to the electrons. The last chapters are devoted to non-equilibrium processes and to kinetic equations, with many applications included.

From Microphysics to Macrophysics