Landau Theory Of Phase Transitions The Application To Structural Incommensurate Magnetic And Liquid Crystal Systems World Scientific Lecture Notes In Physics

Phase transitions in which crystalline solids undergo structural changes present an interesting problem in the interplay between the crystal structure and the ordering process. This text, intended for readers with some prior knowledge of condensed-matter physics, emphasizes the basic physics behind such spontaneous structural changes in crystals. Starting with the relevant thermodynamic principles, the book discusses the nature of order variables and their collective motion in a crystal lattice; in a structural phase transition a singularity in such a collective mode is responsible for the lattice instability, as revealed by soft phonons. This mechanism is analogous to the interplay of a charge-density wave and a periodically deformed lattice in low-dimensional conductors. The text also describes experimental methods for modulated crystal structures and gives examples of structural changes in representative systems. The book is divided into two parts. The first, theoretical, part includes such topics as: the Landau theory of phase transitions; statistics, correlations and the mean-field approximation; pseudospins and their collective modes; soft lattice modes and pseudospin condensates; lattice imperfections and their role in the phase transitions of real crystals. The second part discusses experimental studies of modulated crystals using x-ray diffraction, neutron inelastic scattering, light scattering, dielectric measurements, and magnetic resonance spectroscopy.

This book deals with the phenomenological theory of first-order structural phase transitions, with a special emphasis on reconstructive transformations in which a group-subgroup relationship between the symmetries of the phases is absent. It starts with a unified presentation of the current approach to first-order phase transitions, using the more recent results of the Landau theory of phase transitions and of the theory of singularities. A general theory of reconstructive phase transitions is then formulated, in which the structures surrounding a transition are expressed in terms of density-waves, providing a natural definition of the transition order-parameters, and a description of the corresponding phase diagrams and relevant physical properties. The applicability of the theory is illustrated by a large number of concrete examples pertaining to the various classes of reconstructive transitions: allotropic transformations of the elements, displacive and order-disorder transformations in metals, alloys and related structures, crystal-quasicrystal transformations.

The main subject of the book is the continuum, field theoretic method of study of phase transformations in material systems. The method, also known as "phase field", allows one to analyze different stages of transformations on the unified platform. It has received significant attention in the materials science community recently due to many successes in solving or illuminating important problems. The book will address fundamentals of the method starting from the classical theories of phase transitions, the most important theoretical and computational results, and some of the most advanced recent applications.

Ginzburg-Landau Theory of Phase Transitions in Pseudo-one-dimensional Systems

Application of Landau Theory for the Analysis of Phase Transitions in Minerals

Rigorous Results

Ginzburg-Landau Theory of Phase Transitions in Compactified Spaces

Covering Second-order Phase Transitions, Scale and Conformal Invariance, Algebras of Fluctuating Quantities, Degenerate Systems, Critical Dynamics, Epsilon Expansions, Renormalization Group, and Applications

An extensive summary of mathematical functions that occur in physical and engineering problems

Covering the elementary aspects of the physics of phases transitions and the renormalization group, this popular book is widely used both for core graduate statistical mechanics courses as well as for more specialized courses. Emphasizing understanding and clarity rather than technical manipulation, these lectures de-mystify the subject and show precisely "how things work." Goldenfeld keeps in mind a reader who wants to understand why things are done, what the results are, and what in principle can go wrong. The book reaches both experimentalists and theorists, students and even active researchers, and assumes only a prior knowledge of statistical mechanics at the introductory graduate level.Advanced, never-before-printed topics on the applications of renormalization group far from equilibrium and to partial differential equations add to the uniqueness of this book.

As an introductory account of the theory of phase transitions and critical phenomena, this book reflects lectures given by the authors to graduate students at their departments and is thus classroom-tested to help beginners enter the field. Most parts are written as self-contained units and every new concept or calculation is explained in detail without assuming prior knowledge of the subject. The book significantly enhances and revises a Japanese version which is a bestseller in the Japanese market and is considered a standard textbook in the field. It contains new pedagogical presentations of field theory methods, including a chapter on conformal field theory, and various modern developments hard to find in a single textbook on phase transitions. Exercises are presented as the topics develop, with solutions found at the end of the book, making the text useful for self-teaching, as well as for classroom learning.

The Landau Theory Of Phase Transitions

The Landau Theory of Phase Transitions

Ginzburg-Landau Phase Transition Theory and Superconductivity

Application to Structural, Incommensurate, Magnetic, and Liquid Crystal Systems

On Landau Theory and Symmetric Energy Landscapes for Phase Transitions

Phase transition dynamics is centrally important to condensed matter physics. This 2002 book treats a wide variety of topics systematically by constructing time-dependent Ginzburg-Landau models for various systems in physics, metallurgy and polymer science. Beginning with a summary of advanced statistical-mechanical theories including the renormalization group theory, the book reviews dynamical

theories, and covers the kinetics of phase ordering, spinodal decomposition and nucleation in depth. The phase transition dynamics of real systems are discussed, treating interdisciplinary problems in a unified manner. Topics include supercritical fluid dynamics, stress-diffusion coupling in polymers and mesoscopic dynamics at structural phase transitions in solids. Theoretical and experimental approaches to shear flow problems in fluids are reviewed. Phase Transition Dynamics provides a comprehensive account, building on the statistical mechanics of phase transitions covered in many introductory textbooks. It will be essential reading for researchers and advanced graduate students in physics, chemistry, metallurgy and polymer science.

This textbook describes the fundamental principles of structural phase transitions in materials in an easily understandable form, suitable for both undergraduate and graduate students.

The structural phase transition is one of the most fundamental problems in solid state physics. Layered transition-metal dichalcogenides provide us with a most exciting area for the study of structural phase transitions that are associated with the charge density wave (CDW). A large variety of structural phase transitions, such as commensurate and incommensurate transitions, and the physical proper ties related to the formation of a CDW, have been an object of intense study made for many years by methods employing modem microscopic techniques. Rather recently, efforts have been devoted to the theoretical understanding of these experimental results. Thus, McMillan, for example, has developed an elegant phenomenological theory on the basis of the Landau free energy expansion. An extension of McMillan's theory has provided a successful understanding of the successive phase transitions observed in the IT- and 2H-compounds. In addition, a microscopic theory of lattice instability, lattice dynamics, and lattice distortion in the CDW state of the transition-metal dichalcogenides has been developed based on their electronic structures. As a result, the driving force of the CDW formation in the IT- and 2H-compounds has become clear. Furthermore, the effect of lattice fluctuations on the CDW transition and on the anomalous behavior of various physical properties has been made clear microscopically.

With Formulas, Graphs, and Mathematical Tables

Statistical Mechanics and Applications in Condensed Matter

Handbook of Mathematical Functions

Application of Landau Theory for the Analysis of Phase Transitions in Materials

Landau Theory of Second-order Phase Transitions on Solid Surfaces

About half a century ago Landau formulated the central principles of the phe nomenological second-order phase transition theory which is based on the idea of spontaneous symmetry breaking at phase transition. By means of this ap proach it has been possible to treat phase transitions of different nature in altogether distinct systems from a unified viewpoint, to embrace the aforemen tioned transitions by a unified body of mathematics and to show that, in a certain sense, physical systems in the vicinity of second-order phase transitions exhibit universal behavior. For several decades the Landau method has been extensively used to an alyze specific phase transitions in systems and has been providing a basis for interpreting experimental data on the behavior of physical characteristics near the phase transition, including the behavior of these characteristics in systems subject to various external effects such as pressure, electric and magnetic fields, deformation, etc. The symmetry aspects of Landau's theory are perhaps most effective in analyzing phase transitions in crystals because the relevant body of mathemat ics for this symmetry, namely, the crystal space group representation, has been worked out in great detail. Since particular phase transitions in crystals often call for a subtle symmetry analysis, the Landau method has been continually refined and developed over the past ten or fifteen years.

The present volume contains the courses given at a Summer School on "Magne tic Phase Transitions" held at the Ettore Majorana Centre for Scientific Culture, at Erice (Trapani), Italy in July 1983 under the auspices of the Condensed Matter Division of the European Physical Society in their series on Materials Science and Technology. The student participants came from West Germany, Great Britain, Brazil, Greece, Switzerland, Sweden, Italy, USA and The Netherlands. The lecturers came from various European countries, Israel, USA and Canada. The atmosphere at the meeting was excellent and a good spirit of companion ship developed during two weeks of working together. The spread of interests among the lecturers and students was divers;jfied but balanced. The main lec turing contributions are reported in this volume. They represent up-to-date reviews in a pedagogical style. In addition, informal presentations on cur rent research interests were made which have not been included. The school attempted to summarize the current position on the properties of magnetic phase transitions from several points of view. The range and scope of the oretical techniques, and of particular aspects of materials or phenomena as observed experimentally were very well put forward by the lecturers. The grouping of manuscripts in chapters does not represent, however, the sched ule followed during the school. Contributions on mean-field approximations and renormalization-group methods either for static or dynamic phenomena can be found at various places in the following sections.

The existence of liquid crystals has been known for nearly a centu ry; yet it is only in the last ten years that their unique optical, electri cal, electro-optic, and thermal properties have been exploited to any significant extent in such technological applications as digital d~ plays and thermography. Digital watches equipped with liquid-crys tal displays (LCD's) have recently made their debut in the electronic watch market, and the large-scale use of LCD's in a variety of *other applications requiring reliable, low-power digital displays is immi nent. There is good reason to believe that liquid crystals will be the first electro-optic materials to find widespread commercial use. Apart from applications, liquid crystals are unique among the phases of matter. Lurking beneath their garish display of color and texture is a great complexity of physical and chemical interaction that is only now beginning to unfold in the face of a decade-old resurgence in all aspects of liquid~rystal research. RCA Laboratories has participated in this resurgence from its beginning in the early 1960's and at present maintains active liquid-crystal programs both in basic re search and in device engineering. In view of the widespread interest in liquid crystals at RCA Labo ratories, an in-house weekly seminar devoted to the subject of liquid crystals was organized in the fall of 1973. The resulting lectures were subsequently published in three issues of the RCA Review and, with the incorporation of much additional material, eventually grew into the present volume.*

Application to Structural, Incommensurate, Magnetic and Liquid Crystal Systems

Thermodynamics And Statistical Mechanics

Phase Transitions in Ferroelastic and Co-elastic Crystals

Collected Papers of L.D. Landau

A Primer to the Theory of Critical Phenomena

A Primer to the Theory of Critical Phenomena provides scientists in academia and industry, as well as graduate students in physics, chemistry, and geochemistry with the scientific fundamentals of critical phenomena and phase transitions. The book helps readers broaden their understanding of a field that has developed tremendously over the last forty years. The book also makes a great resource for graduate level instructors at universities. Provides a thorough and accessible treatment of the fundamentals of critical phenomena Offers an in-depth exposition on renormalization and field theory techniques Includes experimental observations of critical effects Includes live examples illustrating the applications of the theoretical material

On June 19th 1999, the European Ministers of Education signed the Bologna Dec laration, with which they agreed that the European university education should be uniformized throughout Europe and based on the two cycle bachelor master's sys tem. The Institute for Theoretical Physics at Utrecht University quickly responded to this new challenge and created an international master's programme in Theoret ical Physics which started running in the summer of 2000. At present, the master's programme is a so called prestige master at Utrecht University, and it aims at train ing motivated students to become sophisticated researchers in theoretical physics. The programme is built on the philosophy that modern theoretical physics is guided by universal principles that can be applied to any sub?eld of physics. As a result, the basis of the master's programme consists of the obligatory courses Statistical Field Theory and Quantum Field Theory. These focus in particular on the general concepts of quantum ?eld theory, rather than on the wide variety of possible applica tions. These applications are left to optional courses that build upon the ?rm concep tual basis given in the obligatory courses.

The subjects of these optional courses in clude, for instance, Strongly Correlated Electrons, Spintronics, Bose Einstein Con densation, The Standard Model, Cosmology, and String Theory.

This book is the fourth in the series of review papers on advanced problems of phase transitions and critical phenomena, the first three volumes appeared in 2004, 2007, and 2012. It presents reviews in those aspects of criticality and related subjects that have currently attracted much attention due to new and essential contributions. The contents are divided into five chapters, and they include: anomalous diffusion, kinetics of pattern formation, scaling, renormalization group approaches in soft matter and socio-physics, Monte Carlo simulation of critical Casimir forces. As with the first three volumes, this book is based on the review lectures that were given in Lviv (Ukraine) at the “Ising lectures” — a traditional annual workshop on phase transitions and critical phenomena which aims to bring together scientists working in these fields with university students and those who are interested in the subject. Contents:Scaling and Finite-Size Scaling above the Upper Critical Dimension (R Kenna and B Berche)Monte Carlo Simulation of Critical Casimir Forces (O A Vasilyev)Non-ergodicity and Ageing in Anomalous Diffusion (R Metzler)Kinetics of Pattern Formation: Mesoscopic and Atomistic Modelling (H Zapolsky)A Renormalization Group Like Model for a Democratic Dictatorship (S Galam) Readership: Researchers, advanced undergraduates and graduate students in physics; non-expert scientists interested in phase transitions and critical phenomena. Keywords:Phase Transitions;Criticality;Scaling;Complex Systems

Phase Transition Dynamics

Elements of Phase Transitions and Critical Phenomena

Ultracold Quantum Fields

Landau Theory and Phase-field Simulations on the Phase Transitions and Domain Structures in Multiferroic Bismuth Ferrite and Hexagonal Manganites

Reconstructive Phase Transitions

This innovative and modular textbook combines classical topics in thermodynamics, statistical mechanics and many-body theory with the latest developments in condensed matter physics research. Written by internationally renowned experts and logically structured to cater for undergraduate and postgraduate students and researchers, it covers the underlying theoretical principles and includes numerous problems and worked examples to put this knowledge into practice. Three main streams provide a framework for the book; beginning with thermodynamics and classical statistical mechanics, including mean field approximation, fluctuations and the renormalization group approach to critical phenomena. The authors then examine quantum statistical mechanics, covering key topics such as normal Fermi and Luttinger liquids, superfluidity and superconductivity. Finally, they explore classical and quantum kinetics, Anderson localization and quantum interference, and disordered Fermi liquids. Unique in providing a bridge between thermodynamics and advanced topics in condensed matter, this textbook is an invaluable resource to all students of physics.

Collected Papers of L. D. Landau brings together the collected papers of L. D. Landau in the field of physics. The discussion is divided into the following sections: low-temperature physics (including superconductivity); solid-state physics; plasma physics;

hydrodynamics; astrophysics; nuclear physics and cosmic rays; quantum mechanics; quantum field theory; and miscellaneous works. Topics covered include the intermediate state of supraconductors; the absorption of sound in solids; the properties of metals at very low temperatures; and production of showers by heavy particles. This volume is comprised of 100 chapters and begins with Landau's paper on the theory of the spectra of diatomic molecules, followed by his studies on the damping problem in wave mechanics; quantum electrodynamics in configuration space; electron motion in crystal lattices; and the internal temperature of stars. Some of Landau's theories, such as those of stars, energy transfer on collisions, phase transitions, and specific heat anomalies are discussed. Subsequent chapters focus on the structure of the undisplaced scattering line; the transport equation in the case of Coulomb interactions; scattering of light by light; and the origin of stellar energy. This book will be a valuable resource for physicists as well as physics students and researchers.

Intended for readers with some prior knowledge of condensed-matter physics, this text emphasises the basic physics behind spontaneous structural changes in crystals. Starting with the relevant thermodynamic principles, the author discusses the nature of order variables and their collective motion in a crystal lattice. He also goes on to describe experimental methods for modulated crystal structures and gives examples of structural changes in representative systems. Both a graduate text and reference work.

Fluctuation Corrections to the Landau Theory of Phase Transitions

Introduction to Liquid Crystals

Order, Disorder and Criticality

Theory of Phase Transitions

In Crystals and Quasicrystals

The contents of this book stems from three different objectives. First, it is an introduction to the basic principles and techniques of Landau's theory, which is intended for teaching purposes. A second purpose of the book provides the practical methods for applying Landau's theory to complex systems. The last objective of the book is to incorporate the developments which have arisen in the last fifteen years from the extensive application of the theory to a variety of physical systems.

Ginzburg-Landau Theory of Phase Transitions in Compactified Spaces.

Multiferroics are materials that simultaneously show multiple ferroic orders, such as ferroelectric, ferromagnetic, and ferroelastic orders. Recently multiferroics attract enormous attentions due to the rich physics and potential applications such as information storage memories. As two important multiferroic materials, $BiFeO_3$ and hexagonal manganites are the focus of the research in this dissertation. An antiferroelectric phase is defined as an antipolar crystal with antiparallel cation displacements of neighboring unit cells. The ferroelectricity and antiferroelectricity in Sm-doped $BiFeO_3$ system are described by a three-dimensional phenomenological model based on the Ginzburg-Landau-

Devonshire theory. The temperature-, pressure-, and composition-induced ferroelectric to antiferroelectric phase transitions are discussed. The constructed temperature-composition and temperature-pressure phase diagrams show that compressive hydrostatic pressure and Sm doping have similar effects on the ferroelectric and antiferroelectric phase transitions. It is also indicated from the temperature-pressure phase diagram that the experimentally observed phase of $BiFeO_3$ under the hydrostatic pressure from 3GPa to 10GPa is a $PbZrO_3$-like antiferroelectric phase.Besides spontaneous polarization, $BiFeO_3$ also shows a structural instability, i.e. oxygen octahedral tilt. Due to the rigidity of the oxygen octahedra and the corner-sharing feature of the oxygen octahedral network, the domain wall energy of the oxygen octahedral tilt has a strong anisotropy with respect to different wall orientations. Based on this, a rotational compatibility condition is proposed to identify the low-energy domain walls in perovskites with oxygen octahedral tilt instability. Applying the rotational compatibility condition to $BiFeO_3$, the unusual ferroelectric domain wall width and energy are successfully explained based on the Ginzburg-Landau-Devonshire theory.Vortex domains in ferroic materials refer to the flux-closure domains in which polarization or magnetization vectors rotate around a point. It is shown that the polarization vortex domains are induced in the $BiFeO_3$ films grown on an electrically insulating substrate. Based on the example, the crystallographic, electric, and strain conditions are proposed to produce spontaneous vortex domains in a ferroelectric film or superlattice. The vortex domains in $BiFeO_3$ give rises to a net curl of the polarization vectors, which is shown to be reversible under external electric fields. The vortex domains in the rhombohedral system without the oxygen octahedral tilt are also studied, which show that the oxygen octahedral tilt has a strong effect on the vortex wall orientations.$BiFeO_3$ shows a rhombohedral (R) crystal structure as bulk materials, and exhibits in R-like phases in the films under a small epitaxial strain. However, recently a tetragonal (T)-like phase is induced by a large compressive strain (larger than 4%). In the dissertation, a Landau-theory-based potential is proposed to describe both the R-like and T-like phases in the $BiFeO_3$ films. The common tangent construction in the phase stability analysis indicates the R/T phase mixture. Based on phase-field simulations, the domain wall orientations of the R/T mixed phases are determined, which are in good agreement with experimental measurements.Different from the perovskite structures of $BiFeO_3$, hexagonal manganites exhibit in a layered hexagonal structure. Hexagonal manganites are a type of improper ferroelectrics with polarization induced by a structural distortion, called trimerization. The trimerization and polarization result in six domains in hexagonal manganites, which can cycle around a point and form a topological defect. Taking $YMnO_3$ as an example, the three-dimensional (3D) domain structure and vortex evolution are studied based on the phase-field method using a thermodynamic potential constructed from density functional theory (DFT) calculations, demonstrating the possibility of predicting 3D complex mesoscale structural evolution starting from

DFT. The temporal evolution of domain and vortex structures allows us to fully explore the mesoscale mechanisms for the vortex-antivortex annihilation, and domain wall motion under external electric fields. It is demonstrated that the vortex motion and vortex-antivortex annilation control the coarsening dynamics of domain structure evolution. The domain structures with topological defects in YMnO3 also show intriguing collective behaviors, which are statistically analyzed based on the phase-field simulation results. It is found that the domain coarsening rate agrees well with the predication of the classical XY model in two dimensions, but shows an unexpected deviation in 3D. Our computational studies suggest that such a deviation arises from the anisotropy in the hexagonal system. In addition, the topological defects in YMnO3 form two types of domain networks: type-I without and type-II with electric self-poling. The frequencies of domains with N-sides, i.e. of N-gons, in a type-I network are fitted by a lognormal distribution, whereas those in type-II display a scale-free power-law distribution with exponent ~2. A preferential attachment process that N-gons with a larger N have higher probability of coalescence is responsible for the emergence of the scale-free networks. Since the domain networks can be observed, analyzed, and manipulated at room temperature, hexagonal manganites provide a unique opportunity to explore how the statistical distribution of a topological defect network evolves with an external electric field.

A Mechanical Analog to Phase Transitions Using the Landau Theory

The Physics of Structural Phase Transitions

Statistical Mechanics of Phase Transitions

Proceedings of a Summer School at the Ettore Majorana Centre, Erice, Italy, 1–15 July, 1983

Magnetic Phase Transitions

This book provides a comprehensive exposition of the theory of equilibrium thermodynamics and statistical mechanics at a level suitable for well-prepared undergraduate students. The fundamental message of the book is that all results in equilibrium thermodynamics and statistical mechanics follow from a single unprovable axiom — namely, the principle of equal a priori probabilities — combined with elementary probability theory, elementary classical mechanics, and elementary quantum mechanics.

This book is an introduction to a comprehensive and unified dynamic transition theory for dissipative systems and to applications of the theory to a range of problems in the nonlinear sciences. The main objectives of this book are to introduce a general principle of dynamic transitions for dissipative systems, to establish a systematic dynamic transition theory, and to explore the physical implications of applications of the theory to a range of problems in the nonlinear sciences. The basic philosophy of the theory is to search for a complete set of transition states, and the general principle states that dynamic transitions of all dissipative systems can be classified into three categories: continuous, catastrophic and random. The audience for this book includes advanced graduate students and researchers in mathematics and physics as well as in other related fields.

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

Phase Transitions and Crystal Symmetry

Advanced Problems of Phase Transition TheoryVolume 4

Fluctuation Theory of Phase Transitions

Structural Phase Transitions in Layered Transition Metal Compounds

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.

Lectures On Phase Transitions And The Renormalization Group

Structural Phase Transitions