

Spin Waves Theory And Applications

In the last two decades low-dimensional (low-d) physics has matured into a major branch of science. Quite generally we may define a system with restricted dimensionality d as an object that is infinite only in one or two spatial directions ($d = 1$ and 2). Such a definition comprises isolated single chains or layers, but also fibres and thin layers (films) of varying but finite thickness. Clearly, a multitude of physical phenomena, notably in solid state physics, fall into these categories. As examples, we may mention:

- Magnetic chains or layers (thin-film technology).
- Metallic films (homogeneous or heterogeneous, crystalline, amorphous or microcrystalline, etc.).
- 1-d or 2-d conductors and superconductors.
- Intercalated systems.
- 2-d electron gases (electrons on helium, semiconductor interfaces).
- Surface layer problems (2-d melting of monolayers of noble gases on a substrate, surface problems in general).
- Superfluid films of ^4He or ^3He .
- Polymer physics.
- Organic and inorganic chain conductors, superionic conductors.
- 1-d or 2-d molecular crystals and liquid crystals.
- 1-d or 2-d ferro- and antiferro electrics.

This book is intended as a basic text for a two-term graduate course for physicists, engineers and chemists with a background in quantum and statistical

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mechanics. What sets it apart from other publications on the subject is its extensive use of Green's function techniques and its detailed discussion of the application of the mean-field approximation and dipole–dipole interactions in one, two and three dimensions. A chapter each has been devoted to low-dimensional systems, surface magnetism and layered systems. A total of 60 exercises have also been included. Contents: Paramagnetism Interacting Spins Mean Field Approximation Spin Waves Green's Functions Methods Dipole–Dipole Interactions Itinerant Magnetism Indirect Exchange Low Dimensions Surface Magnetism Two-Magnon Eigenstates Other Interactions Readership: Teachers of graduate courses and researchers in condensed matter physics and magnetism, as well as graduate students in physics and electronic engineering.

Keywords: Antiferromagnetism; Dipolar Interactions; Ferromagnetism; Quantum Excitations; Itinerant Magnetism; Spin Waves; Low

Dimensions; Magnons; Molecular Field; Paramagnetism Reviews: “This book would be of great use to anyone who desires in-depth theoretical treatment of magnetism.” RIC News “There is a generous sprinkling of problems with solutions, which are challenging and helpful ... this beautifully produced book is a commendable research text which any university library worthy of the name will want to have.” Contemporary Physics “All in all this is a useful and welcome

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addition to the literature on microscopic magnetic material.” Zentralblatt MATH
The ability to understand and control the unique properties of interfaces has created an entirely new field of magnetism, with profound impact in technology and serving as the basis for a revolution in electronics. Our understanding of the physics of magnetic nanostructures has also advanced significantly. This rapid development has generated a need for a comprehensive treatment that can serve as an introduction to the field for those entering it from diverse fields, but which will also serve as a timely overview for those already working in this area. The four-volume work Ultra-Thin Magnetic Structures aims to fulfill this dual need. The original two volumes – now available once more – are An Introduction to the Electronic, Magnetic and Structural Properties (this volume) and "Measurement Techniques and Novel Magnetic Properties." Two new volumes, "Fundamentals of Nanomagnetism" and "Applications of Nanomagnetism," extend and complete this comprehensive work by presenting the foundations of spintronics.

A collection of different lectures presented by experts in the field of nonlinear science provides the reader with contemporary, cutting-edge, research works that bridge the gap between theory and device realizations of nonlinear phenomena. Representative examples of topics covered include: chaos gates,

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social networks, communication, sensors, lasers, molecular motors, biomedical anomalies, stochastic resonance, nano-oscillators for generating microwave signals and related complex systems. A common theme among these and many other related lectures is to model, study, understand, and exploit the rich behavior exhibited by nonlinear systems to design and fabricate novel technologies with superior characteristics. Consider, for instance, the fact that a shark's sensitivity to electric fields is 400 times more powerful than the most sophisticated electric-field sensor. In spite of significant advances in material properties, in many cases it remains a daunting task to duplicate the superior signal processing capabilities of most animals. Since nonlinear systems tend to be highly sensitive to perturbations when they occur near the onset of a bifurcation, there are also lectures on the general topic of bifurcation theory and on how to exploit such bifurcations for signal enhancements purposes. This manuscript will appeal to researchers interested in both theory and implementations of nonlinear systems.

Spin waves (and their quanta magnons) can effectively carry and process information in magnetic nanostructures. By analogy to photonics, this research field is labelled magnonics. It comprises the study of excitation, detection, and manipulation of magnons. From the practical point of view, the most attractive

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feature of magnonic devices is the controllability of their functioning by an external magnetic field. This book has been designed for students and researchers working in magnetism. Here the readers will find review articles written by leading experts working on realization of magnonic devices.

A survey of the main trends in two-dimensional magnetism research, starting with a general introduction to the field of low-dimensional magnetic systems, and progressing to a discussion of the theory of 2-D magnets, the applications of high and low temperature series expansions and spin waves, neutron scattering experiments on 2-D Ising and Heisenb.

Magnetism in Crystalline Materials covers the applications of the theory of groups of cambiant symmetry and the physical properties of magnetically ordered crystalline solids. This book is divided into eight chapters; the first of which discusses the macroscopic properties of magnetic crystals. The structures of magnetically ordered crystals are then explained; this topic is followed by discussions on the theory of corepresentations; magnetic phase transitions; and the tensor properties of magnetic crystals. This text also looks into topics on electrons, lattice vibrations, and spin waves. This selection will be valuable to physicists and to others interested in the magnetism of crystalline materials.

A comprehensive and unified introduction to describing and understanding complex

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interacting systems.

"Quantum Theory of Magnetism" is the only book that deals with the phenomenon of magnetism from the point of view of "linear response". That is, how does a magnetic material respond when excited by a magnetic field? That field may be uniform, or spatially varying, static or time dependent. Previous editions have dealt primarily with the magnetic response. This edition incorporates the resistive response of magnetic materials as well. It also includes problems to test the reader's (or student's) comprehension. The rationale for a book on magnetism is as valid today as it was when the first two editions of Quantum Theory of Magnetism were published. Magnetic phenomena continue to be discovered with deep scientific implications and novel applications. Since the Second Edition, for example, Giant Magneto Resistance (GMR) was discovered and the new field of "spintronics" is currently expanding. Not only do these phenomena rely on the concepts presented in this book, but magnetic properties are often an important clue to our understanding of new materials (e.g., high-temperature superconductors). Their magnetic properties, studied by susceptibility measurements, nuclear magnetic resonance, neutron scattering, etc. have provided insight to the superconductivity state. This updated edition offers revised emphasis on some material as a result of recent developments and includes new material, such as an entire chapter on thin film magnetic multilayers. Researchers and students once again have access to an up-to-date classic reference on magnetism, the key

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characteristic of many modern materials.

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Metallic Spintronic Devices provides a balanced view of the present state of the art of metallic spintronic devices, addressing both mainstream and emerging applications from magnetic tunneling junction sensors and spin torque oscillators to spin torque memory and logic. Featuring contributions from well-known and respected industrial and academic experts, this cutting-edge work not only presents the latest research and developments but also: Describes spintronic applications in current and future magnetic recording devices Discusses spin-transfer torque magnetoresistive random-access memory (STT-MRAM) device architectures and modeling Explores prospects of STT-MRAM scaling, such as detailed multilevel cell structure analysis Investigates spintronic device write and read optimization in light of spintronic memristive effects Considers spintronic research directions based on yttrium iron garnet thin films, including spin pumping, magnetic proximity, spin hall, and spin Seebeck effects Proposes unique solutions for low-power spintronic device applications where memory is closely integrated with logic Metallic Spintronic Devices aims to equip anyone who is serious about metallic spintronic devices with up-to-date design, modeling, and processing knowledge. It can be used either by an expert in the field or a graduate student in course curriculum.

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scattering and THz spectroscopy. Because the measured spectra provide a dynamical fingerprint of a magnetic material, those tools enable scientists to unravel the structure of complex magnetic states and to determine the microscopic interactions that produce them. This book discusses the experimental techniques of inelastic neutron scattering and THz spectroscopy and provides the theoretical tools required to analyze their measurements using spin-wave theory. For most materials, this analysis can resolve the microscopic magnetic interactions such as exchange, anisotropy, and Dzyaloshinskii-Moriya interactions. Assuming a background in elementary statistical mechanics and a familiarity with the quantized harmonic oscillator, this book presents a comprehensive review of spin-wave theory and its applications to both inelastic neutron scattering and THz spectroscopy. Spin-wave theory is used to study several model magnetic systems, including non-collinear magnets such as spirals and cycloids that are produced by geometric frustration, competing exchange interactions, or Dzyaloshinskii-Moirya interactions. Several case studies utilizing spin-wave theory to analyze inelastic neutron-scattering and THz spectroscopy measurements are presented. These include both single crystals and powders and both oxides and molecule-based magnets. In addition to sketching the numerical techniques used to fit dynamical spectra based on microscopic models, this book also contains over 70 exercises that can be performed by beginning graduate students. Magnetic and spintronic materials are ubiquitous in modern technological applications,

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e.g. in electric motors, power generators, sensors and actuators, not to mention information storage and processing. Medical technology has also greatly benefited from magnetic materials – especially magnetic nanoparticles – for therapy and diagnostics methods. All of the above-mentioned applications rely on the properties of the materials used. These properties in turn depend on intrinsic and extrinsic material parameters. The former are related to the actual elements used and their properties, e.g. atomic magnetic moment and exchange interaction between atoms; the latter are related to the structural and microstructural properties of the materials used, e.g. their crystal structure, grain size, and grain boundary phases. Focusing on state-of-the-art magnetic and spintronic materials, this book will introduce readers to a range of related topics in Physics and Materials Science. Phenomena and processes at the nanoscale are of particular importance in this context; accordingly, much of the book addresses such topics.

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Because future microwave, magnetic resonance, and wave propagation systems will involve miniature devices, nanosize structures, multifunctional applications, and composites of various types of materials, their development requires distinctly multidisciplinary collaborations. That means specialized approaches will not be sufficient to satisfy requirements. Anticipating that many students lack specialized training in magnetism and magnetics, Magnetics, Dielectrics, and Wave Propagation with MATLAB® Codes avoids application-specific descriptions. Instead, it connects phenomenological approaches with comprehensive microscopic formulations to provide a new and sufficiently broad physical perspective on modern trends in microwave

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technology. Reducing complex calculation approaches to their simplest form, this book's strength is in its step-by-step explanation of the procedure for unifying Maxwell's equations with the free energy via the equation of motion. With clear and simple coverage of everything from first principles to calculation tools, it revisits the fundamentals that govern the phenomenon of magnetic resonance and wave propagation in magneto-dielectric materials. Introduces constitutive equations via the free energy, paving the way to consider wave propagation in any media This text helps students develop an essential understanding of the origin of magnetic parameters from first principles, as well as how these parameters are to be included in the large-scale free energy. More importantly, it facilitates successful calculation of said parameters, which is required as the dimensionality of materials is reduced toward the microscopic scale. The author presents a systematic way of deriving the permeability tensor of the most practical magnetic materials, cubic and hexagonal crystal structures. Using this simple and very general approach, he effectively bridges the gap between microscopic and macroscopic principles as applied to wave propagation.

High-Temperature Cuprate Superconductors provides an up-to-date and comprehensive review of the properties of these fascinating materials. The essential properties of high-temperature cuprate superconductors are reviewed on the background of their theoretical interpretation. The experimental results for structural, magnetic, thermal, electric, optical and lattice properties of various cuprate superconductors are presented with respect to relevant theoretical models. A critical comparison of various theoretical models involving strong electron correlations, antiferromagnetic spin fluctuations, phonons and excitons provides a background for understanding of the mechanism of high-temperature superconductivity. Recent

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achievements in their applications are also reviewed. A large number of illustrations and tables gives valuable information for specialists. A text-book level presentation with formulation of a general theory of strong-coupling superconductivity will help students and researchers to consolidate their knowledge of this remarkable class of materials.

The main goal of the book is a coherent treatment of the theory of propagation in materials of nonlinearly elastic waves of displacements, which corresponds to one modern line of development of the nonlinear theory of elastic waves. The book is divided on five basic parts: the necessary information on waves and materials; the necessary information on nonlinear theory of elasticity and elastic materials; analysis of one-dimensional nonlinear elastic waves of displacement – longitudinal, vertically and horizontally polarized transverse plane nonlinear elastic waves of displacement; analysis of one-dimensional nonlinear elastic waves of displacement – cylindrical and torsional nonlinear elastic waves of displacement; analysis of two-dimensional nonlinear elastic waves of displacement – Rayleigh and Love nonlinear elastic surface waves. The book is addressed first of all to people working in solid mechanics – from the students at an advanced undergraduate and graduate level to the scientists, professionally interesting in waves. But mechanics is understood in the broad sense, when it includes mechanical and other engineering, material science, applied mathematics and physics and so forth. The genesis of this book can be found in author's years of research and teaching while a head of department at SP Timoshenko Institute of Mechanics (National Academy of Sciences of Ukraine), a member of Center for Micro and Nanomechanics at Engineering School of University of Aberdeen (Scotland) and a professor at Physical-Mathematical Faculty of National Technical University of Ukraine "KPI". The book comprises 11 chapters. Each

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chapter is complemented by exercises, which can be used for the next development of the theory of nonlinear waves.

This book reports on recent progress in emerging technologies, modern characterization methods, theory and applications of advanced magnetic materials. It covers broad spectrum of topics: technology and characterization of rapidly quenched nanowires for information technology; fabrication and properties of hexagonal ferrite films for microwave communication; surface reconstruction of magnetite for spintronics; synthesis of multiferroic composites for novel biomedical applications, optimization of electroplated inductors for microelectronic devices; theory of magnetism of Fe-Al alloys; and two advanced analytical approaches for modeling of magnetic materials using Everett integral and the inverse problem approach. This book is addressed to a diverse group of readers with general background in physics or materials science, but it can also benefit specialists in the field of magnetic materials.

Advances in the synthesis of new materials with often complex, nano-scaled structures require increasingly sophisticated experimental techniques that can probe the electronic states, the atomic magnetic moments and the magnetic microstructures responsible for the properties of these materials. At the same time, progress in synchrotron radiation techniques has ensured that these light sources remain a key tool of investigation, e.g. synchrotron radiation sources of the third generation are able to support magnetic imaging on a sub-micrometer scale. With the Sixth Mittelwihl School on Magnetism and Synchrotron Radiation the tradition of teaching the state-of-the-art on modern research developments continues and is expressed through the present set of extensive lectures provided in this volume. While primarily aimed at postgraduate students and newcomers to the field, this volume will also benefit researchers

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and lecturers actively working in the field.

The book *Ferromagnetic Resonance - Theory and Applications* highlights recent advances at the interface between the science and technology of nanostructures (bilayer-multilayers, nanowires, spinel type nanoparticles, photonic crystal, etc.). The electromagnetic resonance techniques have become a central field of modern scientific and technical activity. The modern technical applications of ferromagnetic resonance are in spintronics, electronics, space navigation, remote-control equipment, radio engineering, electronic computers, maritime, electrical engineering, instrument-making and geophysical methods of prospecting.

Advances in Quantum Chemistry presents surveys of current topics in this rapidly developing field that has emerged at the cross section of the historically established areas of mathematics, physics, chemistry, and biology. It features detailed reviews written by leading international researchers. This series provides a one-stop resource for following progress in this interdisciplinary area. Publishes articles, invited reviews and proceedings of major international conferences and workshops Written by leading international researchers in quantum and theoretical chemistry Highlights important interdisciplinary developments

Nanomagnetic and spintronic computing devices are strong contenders for future replacements of CMOS. This is an important and rapidly evolving area with the semiconductor industry investing significantly in the study of nanomagnetic phenomena and in developing strategies to pinpoint and regulate nanomagnetic reliably with a high degree of energy efficiency. This timely book explores the recent and on-going research into nanomagnetic-based technology. Key features: Detailed background

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material and comprehensive descriptions of the current state-of-the-art research on each topic. Focuses on direct applications to devices that have potential to replace CMOS devices for computing applications such as memory, logic and higher order information processing. Discusses spin-based devices where the spin degree of freedom of charge carriers are exploited for device operation and ultimately information processing. Describes magnet switching methodologies to minimize energy dissipation. Comprehensive bibliographies included for each chapter enabling readers to conduct further research in this field. Written by internationally recognized experts, this book provides an overview of a rapidly burgeoning field for electronic device engineers, field-based applied physicists, material scientists and nanotechnologists. Furthermore, its clear and concise form equips readers with the basic understanding required to comprehend the present stage of development and to be able to contribute to future development. Nanomagnetic and Spintronic Devices for Energy-Efficient Memory and Computing is also an indispensable resource for students and researchers interested in computer hardware, device physics and circuits design.

Ferromagnetic Resonance: The Phenomenon of Resonant Absorption of a High - Frequency Magnetic Field in Ferromagnetic Substances is a collection of papers on the basic theory of ferromagnetic resonance. The book discusses the theory of ferromagnetic resonance in detail and the investigations and treatments of problems in this theory. The text consists of nine chapters covering such topics as the linear

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approximation of ferromagnetic resonance; non-linear processes occurring during ferromagnetic resonance in ferromagnetic semiconductor; the spin-wave theory of ferro- and antiferromagnetism and its application to the problem of ferromagnetic resonance; and the theory of the line width of the resonance absorption of the energy of a UHF field in ferromagnetics. Physicists will find the book very useful.

Magnetostatic Waves and their Applications is the first book devoted to magnetostatic waves. The book gives a thorough review of the field suitable for scientists, engineers and advanced students involved in magnetism and microwave electronics new to this area. It covers the field from essential physics to applications in microwave electronics, with details of the materials and materials processing methods included.

The Frontiers in Materials Editorial Office team are delighted to present the second edition of the “Rising Stars” article collection, “Frontiers in Materials: Rising Stars 2020”, showcasing the high-quality work of internationally recognized researchers in the early stages of their independent careers. All Rising Star researchers featured within this collection were individually nominated by the Topic Editors in recognition of their potential to influence the future directions of their respective fields. The work presented here highlights the diversity of research performed across the entire breadth of the materials science and engineering field and presents advances in theory, experimentation, and methodology with applications for solving compelling problems. This Editorial features the corresponding author(s) of each paper published within this

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important collection, ordered by section alphabetically, highlighting them as the great researchers of the future. The Frontiers in Materials Editorial Office team would like to thank each researcher who contributed their work to this collection. We would also like to personally thank the Topic Editors for their exemplary leadership of this article collection; their strong support and passion for this important, community-driven collection has ensured its success and global impact. Emily Young Journal Development Manager

In the past few years, there has been a rapidly growing interest in the properties of spin waves (or magnons) in ordered magnetic materials. These are the low-lying excitations that characterize the dynamical behavior of the magnetization variables in ferromagnets, ferrimagnets and antiferromagnets, particularly at low temperatures. Many of the recent developments concerning spin waves have been directed towards understanding their behavior in limited magnetic samples. At the same time, there have been dramatic advances in the experimental techniques, both for preparing high-quality magnetic samples in the form of thin films and superlattices and for the study of the spin-wave excitations themselves. Magnetic thin films have long been of technological as well as scientific interest and an understanding of both the linear and nonlinear aspects of their magnetic behavior is important.

The book is intended for graduate students and researchers who wish to master the main properties of magnetic materials in the bulk state and at the nanometric scale

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such as for thin films and multilayers. This textbook provides the theories and methods of simulation to study and to understand these properties in an explicit manner. In the first part of the book, the quantum theory of magnetism is presented while the second part of the book is devoted to the application of the theory of magnetism to surface physics. Numerous examples covering typical cases in ferromagnets, antiferromagnets, ferrimagnets, helimagnets, and frustrated spin systems are all illustrated. Fundamental surface effects are shown and discussed. Lastly, the spin transport is described — in which the basic formulation of the Boltzmann's equation is recalled — and the recent methods of Monte Carlo simulation to deal with the spin resistivity are explained. This book contains a large number of detailed solutions for the problems given in each chapter to help readers discover new related phenomena and applications, as well as an appendix on elements of statistical physics included at the end to make the book self-contained.

This book presents a collection of problems in spin wave excitations with their detailed solutions. Each chapter briefly introduces the important concepts, encouraging the reader to further explore the physics of spin wave excitations and the engineering of spin wave devices by working through the accompanying problem sets. The initial chapters cover the fundamental aspects of magnetization, with its origins in quantum mechanics, followed by chapters on spin wave excitations, such as the magnetostatic approximation, Walker's equation, the spin wave manifold in the three different

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excitation geometries of forward volume, backward volume and surface waves, and the dispersion of spin waves. The latter chapters focus on the practical aspects of spin waves and spin wave optical devices and use the problem sets to introduce concepts such as variational analysis and coupled mode theory. Finally, for the more advanced reader, the book covers nonlinear interactions and topics such as spin wave quantization, spin torque excitations, and the inverse Doppler effect. The topics range in difficulty from elementary to advanced. All problems are solved in detail and the reader is encouraged to develop an understanding of spin wave excitations and spin wave devices while also strengthening their mathematical, analytical, and numerical programming skills.

The topic of lattice quantum spin systems is a fascinating and by now well established branch of theoretical physics. Based on a set of lectures, this book has a level of detail missing from others, and guides the reader through the fundamentals of the field.

Quantum sensing is a vast and emerging field enabling in-situ studies of quantum systems and hence the development of quantum hybrid systems. This work creates the fundament of direct superconducting-magnetic hybrid systems by developing a local microwave sensing scheme and studying the influence of a static magnetic field on a superconducting qubit. Finally, a proof-of-principle

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hybrid system is demonstrated, which opens the path towards superconducting-magnetic quantum circuits.

This book begins by introducing magnetism and discusses magnetic properties of materials, magnetic moments of atoms and ions, and the elements important to magnetism. It covers magnetic susceptibilities and electromagnetic waves in anisotropic dispersive media among other topics. There are problems at the end of each chapter, many of which serve to expand or explain the material in the text. The bibliographies for each chapter give an entry to the research literature.

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