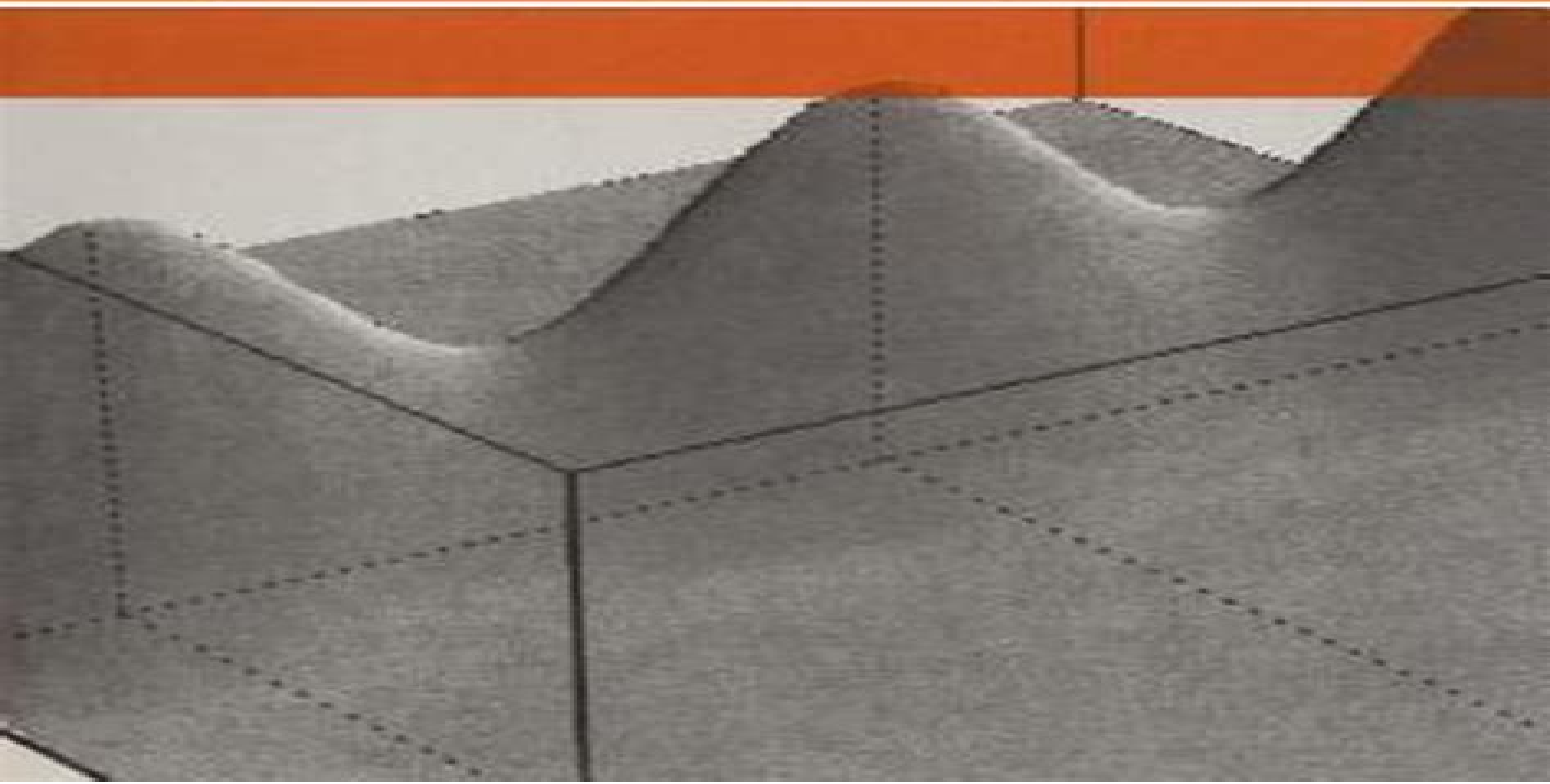


Cambridge Studies in Magnetism

# Macroscopic Quantum Tunneling of the Magnetic Moment

Eugene M Chudnovsky and Javier Tejada



# Macroscopic Quantum Tunneling Of The Magnetic Moment

**Oleg Grinberg, Lawrence J. Berliner**



## **Macroscopic Quantum Tunneling Of The Magnetic Moment:**

*Macroscopic Quantum Tunneling of the Magnetic Moment* Eugene M. Chudnovsky, Javier Tejada, 1998-08-28 This is the first book to present a coherent theoretical and experimental treatment of the rapidly developing field of macroscopic quantum tunneling of the magnetic moment The theory is based on the concept of the magnetic instanton and its renormalization by the dissipative environment The book includes discussions of the tunneling of magnetic moment in small ferromagnetic grains tunneling of the Néel vector in antiferromagnetic grains quantum nucleation of magnetic domains and quantum depinning of domain walls The experimental part collects the majority of recent data that are or may be relevant to spin tunneling Among the topics described are low temperature magnetic relaxation and its interpretation in various systems experiments on single particles and mesoscopic wires and resonant spin tunneling in molecular magnets This study of an important new field in condensed matter physics by two leading contributors to the subject will be of interest to theorists and experimentalists

**Macroscopic Quantum Tunneling** Shin Takagi, 2002-08-15 A coherent and self contained account of macroscopic quantum phenomena for graduate students and researchers

*Quantum Tunneling of Magnetization — QTM '94* Leon Gunther, B. Barbara, 2012-12-06 The first NATO Advanced Workshop on Quantum Tunneling of Magnetization QTM was organized and co directed by Bernard Barbara Leon Gunther Nicolas Garcia and Anthony Leggett and was held from June 27 through July 1 1994 in Grenoble and Chichilianne France These Proceedings include twenty nine articles that represent the contributions of the participants in the Workshop Quantum Tunneling of Magnetization is not only interesting for purely academic reasons It was pointed out in the review article by L Gunther in the December 1990 issue of Physics World that QTM may be destined to play a significant role within the next two decades in limiting the density of information storage in magnetic systems Recent advances have indicated that this limitation may well be reached even earlier than first predicted Furthermore the number of people who have entered the field of study of QTM during these past few years has increased many fold The time was therefore opportune to hold a Workshop to bring together for the first time the leading researchers of QTM both theoretical and experimental so as to discuss the current status of the field The most controversial issue at the time of the Workshop was how to establish reliable criteria for determining whether experimental results do indeed reveal manifestations of QTM We believe that much progress was made at the Workshop on this issue

The Langevin Equation William Coffey, Yu. P. Kalmykov, 2012 This volume is the third edition of the first ever elementary book on the Langevin equation method for the solution of problems involving the translational and rotational Brownian motion of particles and spins in a potential highlighting modern applications in physics chemistry electrical engineering and so on In order to improve the presentation to accommodate all the new developments and to appeal to the specialized interests of the various communities involved the book has been extensively rewritten and a very large amount of new material has been added This has been done in order to present a comprehensive overview of the subject emphasizing via a synergetic

approach that seemingly unrelated physical problems involving random noise may be described using virtually identical mathematical methods in the spirit of the founders of the subject viz Einstein Langevin Smoluchowski Kramers The book has been written in such a way that all the material should be accessible both to an advanced researcher and a beginning graduate student It draws together in a coherent fashion a variety of results which have hitherto been available only in the form of scattered research papers and review articles

**Handbook of Advanced Magnetic Materials** Yi Liu,D.J. Sellmyer,Daisuke Shindo,2008-11-23 In December 2002 the world s first commercial magnetic levitation super train went into operation in Shanghai The train is held just above the rails by magnetic levitation maglev and can travel at a speed of 400 km hr completing the 30km journey from the city to the airport in minutes Now consumers are enjoying 50 GB hard drives compared to 0.5 GB hard drives ten years ago Achievements in magnetic materials research have made dreams of a few decades ago reality The objective of the four volume reference Handbook of Advanced Magnetic Materials is to provide a comprehensive review of recent progress in magnetic materials research Each chapter will have an introduction to give a clear definition of basic and important concepts of the topic The details of the topic are then elucidated theoretically and experimentally New ideas for further advancement are then discussed Sufficient references are also included for those who wish to read the original work In the last decade one of the most significant thrust areas of materials research has been nanostructured magnetic materials There are several critical sizes that control the behavior of a magnetic material and size effects become especially critical when dimensions approach a few nanometers where quantum phenomena appear The first volume of the book Nanostructured Advanced Magnetic Materials has therefore been devoted to the recent development of nanostructured magnetic materials emphasizing size effects Our understanding of magnetism has advanced with the establishment of the theory of atomic magnetic moments and itinerant magnetism Simulation is a powerful tool for exploration and explanation of properties of various magnetic materials Simulation also provides insight for further development of new materials Naturally before any simulation can be started a model must be constructed This requires that the material be well characterized Therefore the second volume Characterization and Simulation provides a comprehensive review of both experimental methods and simulation techniques for the characterization of magnetic materials After an introduction each section gives a detailed description of the method and the following sections provide examples and results of the method Finally further development of the method will be discussed The success of each type of magnetic material depends on its properties and cost which are directly related to its fabrication process Processing of a material can be critical for development of artificial materials such as multilayer films clusters etc Moreover cost effective processing usually determines whether a material can be commercialized In recent years processing of materials has continuously evolved from improvement of traditional methods to more sophisticated and novel methods The objective of the third volume Processing of Advanced Magnetic Materials is to provide a comprehensive review of recent developments in processing of advanced

magnetic materials Each chapter will have an introduction and a section to provide a detailed description of the processing method The following sections give detailed descriptions of the processing properties and applications of the relevant materials Finally the potential and limitation of the processing method will be discussed The properties of a magnetic material can be characterized by intrinsic properties such as anisotropy saturation magnetization and extrinsic properties such as coercivity The properties of a magnetic material can be affected by its chemical composition and processing route With the continuous search for new materials and invention of new processing routes magnetic properties of materials cover a wide spectrum of soft magnetic materials hard magnetic materials recording materials sensor materials and others The objective of the fourth volume Properties and Applications of Advanced Magnetic Materials is to provide a comprehensive review of recent development of various magnetic materials and their applications Each chapter will have an introduction of the materials and the principles of their applications The following sections give a detailed description of the processing properties and applications Finally the potential and limitation of the materials will be discussed

□□□□□□□□□□(21□□□□□□□□□□1□) David J. Sellmyer,2005      **Comprehensive Nanoscience and Technology** ,2010-10-29 From the Introduction Nanotechnology and its underpinning sciences are progressing with unprecedented rapidity With technical advances in a variety of nanoscale fabrication and manipulation technologies the whole topical area is maturing into a vibrant field that is generating new scientific research and a burgeoning range of commercial applications with an annual market already at the trillion dollar threshold The means of fabricating and controlling matter on the nanoscale afford striking and unprecedented opportunities to exploit a variety of exotic phenomena such as quantum nanophotonic and nanoelectromechanical effects Moreover researchers are elucidating new perspectives on the electronic and optical properties of matter because of the way that nanoscale materials bridge the disparate theories describing molecules and bulk matter Surface phenomena also gain a greatly increased significance even the well known link between chemical reactivity and surface to volume ratio becomes a major determinant of physical properties when it operates over nanoscale dimensions Against this background this comprehensive work is designed to address the need for a dynamic authoritative and readily accessible source of information capturing the full breadth of the subject Its six volumes covering a broad spectrum of disciplines including material sciences chemistry physics and life sciences have been written and edited by an outstanding team of international experts Addressing an extensive cross disciplinary audience each chapter aims to cover key developments in a scholarly readable and critical style providing an indispensable first point of entry to the literature for scientists and technologists from interdisciplinary fields The work focuses on the major classes of nanomaterials in terms of their synthesis structure and applications reviewing nanomaterials and their respective technologies in well structured and comprehensive articles with extensive cross references It has been a constant surprise and delight to have found amongst the rapidly escalating number who work in nanoscience and technology so many highly esteemed authors willing to contribute

Sharing our anticipation of a major addition to the literature they have also captured the excitement of the field itself in each carefully crafted chapter Along with our painstaking and meticulous volume editors full credit for the success of this enterprise must go to these individuals together with our thanks for largely adhering to the given deadlines Lastly we record our sincere thanks and appreciation for the skills and professionalism of the numerous Elsevier staff who have been involved in this project notably Fiona Geraghty Megan Palmer and Greg Harris and especially Donna De Weerd Wilson who has steered it through from its inception We have greatly enjoyed working with them all as we have with each other

**Tunneling in Complex Systems** Steven Tomsovic, 1998 The influential political philosopher Leo Strauss has been credited by conservatives with the recovery of the great tradition of political philosophy stretching back to Plato Among Strauss s most enduring legacies is a strongly negative assessment of Nietzsche as the modern philosopher most at odds with that tradition and most responsible for the sins of twentieth century culture relativism godlessness nihilism and the breakdown of family values In fact this apparent denunciation has become so closely associated with Strauss that it is often seen as the very core of his thought In *Leo Strauss and Nietzsche* the eminent Nietzsche scholar Laurence Lampert offers a controversial new assessment of the Strauss Nietzsche connection Lampert undertakes a searching examination of the key Straussian essay *Note on the Plan of Nietzsche s Beyond Good and Evil* He shows that this essay written toward the end of Strauss s life and placed at the center of his final work reveals an affinity for and debt to Nietzsche greater than Strauss s followers allow Lampert argues that the essay comprises the most important interpretation of Nietzsche ever published one that clarifies Nietzsche s conception of nature and of human spiritual history and demonstrates the logical relationship between the essential themes in Nietzsche s thought the will to power and the eternal return

*Molecular Magnets* Juan Bartolomé, Fernando Luis, Julio F. Fernández, 2013-10-17 This book provides an overview of the physical phenomena discovered in magnetic molecular materials over the last 20 years It is written by leading scientists having made the most important contributions to this active area of research The main topics of this book are the principles of quantum tunneling and quantum coherence of single molecule magnets SMMs phenomena which go beyond the physics of individual molecules such as the collective behavior of arrays of SMMs the physics of one dimensional single chain magnets and magnetism of SMMs grafted on substrates The potential applications of these physical phenomena to classical and quantum information communication technologies and the emerging fields of molecular spintronics and magnetic refrigeration are stressed The book is written for graduate students researchers and non experts in this field of research

*Comprehensive Nanoscience and Nanotechnology*, 2019-01-02 *Comprehensive Nanoscience and Technology* Second Edition Five Volume Set allows researchers to navigate a very diverse interdisciplinary and rapidly changing field with up to date comprehensive and authoritative coverage of every aspect of modern nanoscience and nanotechnology Presents new chapters on the latest developments in the field Covers topics not discussed to this degree of detail in other works such as biological devices and

applications of nanotechnology Compiled and written by top international authorities in the field     Langevin Equation, The: With Applications To Stochastic Problems In Physics, Chemistry And Electrical Engineering (3rd Edition) Yuri P Kalmykov, William T Coffey, 2012-07-31 This volume is the third edition of the first ever elementary book on the Langevin equation method for the solution of problems involving the translational and rotational Brownian motion of particles and spins in a potential highlighting modern applications in physics chemistry electrical engineering and so on In order to improve the presentation to accommodate all the new developments and to appeal to the specialized interests of the various communities involved the book has been extensively rewritten and a very large amount of new material has been added This has been done in order to present a comprehensive overview of the subject emphasizing via a synergetic approach that seemingly unrelated physical problems involving random noise may be described using virtually identical mathematical methods in the spirit of the founders of the subject viz Einstein Langevin Smoluchowski Kramers etc The book has been written in such a way that all the material should be accessible both to an advanced researcher and a beginning graduate student It draws together in a coherent fashion a variety of results which have hitherto been available only in the form of scattered research papers and review articles     **Quantum Dissipative Systems (Fifth Edition)** Ulrich Weiss, 2021-09-21 This comprehensive textbook provides the fundamental concepts and methods of dissipative quantum mechanics and related issues in condensed matter physics starting from first principles It deals with the phenomena and theory of decoherence relaxation and dissipation in quantum mechanics that arise from the random exchange of energy with the environment Major theoretical advances in combination with stunning experimental achievements and the arising perspective for quantum computing have brightened the field and brought it to the attention of the general community in natural sciences Expertise in dissipative quantum mechanics is by now beneficial in a broad sphere This book originally published in 1992 and republished as enlarged and updated second third and fourth edition in 1999 2008 and 2012 dives even deeper into the fundamental concepts methods and applications of quantum dissipation The fifth edition provides a self contained and updated account of the quantum mechanics and quantum statistics of open systems The subject matter of the book has been thoroughly revised to better comply with the needs of newcomers and the demands of the advanced readership Most of the chapters are rewritten to enhance clarity and topicality Four new chapters covering recent developments in the field have been added There are about 600 references This book is intended for use by advanced undergraduate and graduate students in physics and for researchers active in the field They will find the monograph as a rich and stimulating source     Quantum Field Theory in Condensed Matter Physics Alexei M. Tsvelik, 2007-01-18 A new edition of a successful advanced text in condensed matter physics     *Very High Frequency (VHF) ESR/EPR* Oleg Grinberg, Lawrence J. Berliner, 2013-11-09 The field of Very High Frequency EPR VHF EPR or sometimes called Very High Field EPR conveniently also abbreviated as VHF EPR has blossomed during the past decade especially after the original pioneering work of Ya S Lebedev and his group at the Institute

of Chemical Physics Russian Academy of Sciences in Moscow Although Lebedev suffered heavily under the economic constraints of the communist Soviet Union and then succumbed to cancer at the peak of his scientific career his groundbreaking work from the 1970 s is still considered today to be the gold standard by researchers practicing EPR at high magnetic fields A stimulus for the production of this book is the legacy of Yakov Levedev in his students now residing in academic positions in the US and elsewhere The aim of this book is to highlight the state of this growing field This is an attempt to cover the full scope of VHF EPR in a single volume The idea for this volume came to the editors at the 2001 Rocky Mountain Analytical Conference during the 24th International EPR Symposium chaired by Sandra and Gareth Eaton VHF EPR was presented as an independent research field at a workshop organized by LC Brunel and supported by the National High Magnetic Field Laboratory a National Science Foundation funded facility at Florida State University

**Langevin Equation, The: With Applications To Stochastic Problems In Physics, Chemistry And Electrical Engineering (Fourth Edition)** William T Coffey, Yuri P Kalmykov, 2017-03-22 Our original objective in writing this book was to demonstrate how the concept of the equation of motion of a Brownian particle the Langevin equation or Newtonian like evolution equation of the random phase space variables describing the motion first formulated by Langevin in 1908 so making him inter alia the founder of the subject of stochastic differential equations may be extended to solve the nonlinear problems arising from the Brownian motion in a potential Such problems appear under various guises in many diverse applications in physics chemistry biology electrical engineering etc However they have been invariably treated following the original approach of Einstein and Smoluchowski via the Fokker Planck equation for the evolution of the probability density function in phase space Thus the more simple direct dynamical approach of Langevin which we use and extend here has been virtually ignored as far as the Brownian motion in a potential is concerned In addition two other considerations have driven us to write this new edition of The Langevin Equation First more than five years have elapsed since the publication of the third edition and following many suggestions and comments of our colleagues and other interested readers it became increasingly evident to us that the book should be revised in order to give a better presentation of the contents In particular several chapters appearing in the third edition have been rewritten so as to provide a more direct appeal to the particular community involved and at the same time to emphasize via a synergetic approach how seemingly unrelated physical problems all involving random noise may be described using virtually identical mathematical methods Secondly in that period many new and exciting developments have occurred in the application of the Langevin equation to Brownian motion Consequently in order to accommodate all these a very large amount of new material has been added so as to present a comprehensive overview of the subject

Advances in Chemical Physics, Volume 153 Stuart A. Rice, Aaron R. Dinner, 2013-03-19 Detailed reviews of new and emerging topics in chemical physics presented by leading experts The Advances in Chemical Physics series is dedicated to reviewing new and emerging topics as well as the latest developments in



traditional areas of study in the field of chemical physics Each volume features detailed comprehensive analyses coupled with individual points of view that integrate the many disciplines of science that are needed for a full understanding of chemical physics Volume 153 of *Advances in Chemical Physics* features six expertly written contributions Recent advances of ultrafast X ray absorption spectroscopy for molecules in solution Scaling perspective on intramolecular vibrational energy flow analogies insights and challenges Longest relaxation time of relaxation processes for classical and quantum Brownian motion in a potential escape rate theory approach Local fluctuations in solution theory and applications Macroscopic effects of microscopic heterogeneity Ab initio methodology for pseudospin Hamiltonians of anisotropic magnetic centers Reviews published in *Advances in Chemical Physics* are typically longer than those published in journals providing the space needed for readers to fully grasp the topic the fundamentals as well as the latest discoveries applications and emerging avenues of research Extensive cross referencing enables readers to explore the primary research studies underlying each topic *Advances in Chemical Physics* is ideal for introducing novices to topics in chemical physics Moreover the series provides the foundation needed for more experienced researchers to advance their own research studies and continue to expand the boundaries of our knowledge in chemical physics

*Handbook of Superconductivity* David A. Cardwell, David C. Larbalestier, Aleksander Braginski, 2022-07-05 This is the first of three volumes of the extensively revised and updated second edition of the *Handbook of Superconductivity* The past twenty years have seen rapid progress in superconducting materials which exhibit one of the most remarkable physical states of matter ever to be discovered Superconductivity brings quantum mechanics to the scale of the everyday world where a single coherent quantum state may extend over a distance of metres or even kilometres depending on the size of a coil or length of superconducting wire Viable applications of superconductors rely fundamentally on an understanding of this intriguing phenomena and the availability of a range of materials with bespoke properties to meet practical needs This first volume covers the fundamentals of superconductivity and the various classes of superconducting materials which sets the context and background for Volumes 2 and 3 Key Features Covers the depth and breadth of the field Includes contributions from leading academics and industry professionals across the world Provides hands on guidance to the manufacturing and processing technologies A comprehensive reference this handbook is suitable for both graduate students and practitioners in experimental physics materials science and multiple engineering disciplines including electronic and electrical chemical mechanical metallurgy and others

**Magnetic Properties of Fine Particles** J.L. Dormann, D. Fiorani, 2012-12-02 The aim of this volume is to advance the understanding of the fundamental properties of fine magnetic particles and to discuss the latest developments from both the theoretical and experimental viewpoints with special emphasis being placed on the applications in different branches of science and technology All aspects of fine magnetic particles are covered in the 46 papers The topics are remarkably interdisciplinary covering theory materials preparation structural characterization optical and electrical properties magnetic properties studied by different techniques

and applications Some new fundamental properties such as quantum tunneling and transverse fluctuations of magnetic moments are also explored Research workers involved in these aspects of materials technology will find this book of great interest

**Advances in Chemical Physics** Ilya Prigogine, Stuart A. Rice, 2009-09-09 This is the only series of volumes available that represents the cutting edge of research relative to advances in chemical physics Provides the chemical physics field with a forum for critical authoritative evaluations of advances in every area of the discipline Continues to report recent advances with significant up to date chapters Contributing authors are internationally recognized researchers

**Frontiers in Magnetism of Reduced Dimension Systems** Victor G. Bar'yakhtar, P.E. Wigen, 2012-12-06 Frontiers in Magnetism of Reduced Dimension Systems presents a definitive statement of our current knowledge and the state of the art in a field that has yet to achieve maturity even though there are a number of potential applications of thin magnetic films and multilayers such as magnetic sensors data storage retrieval media actuators etc The book is organized into 13 chapters each including a lecture and contributed papers on a similar subject Five chapters deal with theoretical descriptions of electron transport phenomena relaxation processes nonlinear paramagnetic interactions phase transitions and macroscopic quantum effects in magnetic films and particles The description of different characterization techniques occupies an important place in the book Separate chapters are dedicated to magnetic resonances FMR SWR NMR magneto optical spectroscopy controlling chaos magnetoelastic phenomena and magnetic resonance force microscopy A further chapter gives a detailed review spread over a number of papers of materials in current use in information storage devices

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