



Electron Holography

Daisuke Shindo, Zentaro Akase



Electron Holography:

ELECTRON HOLOGRAPHY. Akira Tonomura,1999-07-02 This is an introduction to electron holography a newly developed technique for observing and measuring microscopic structures of matter and fields using the wave nature of electrons It describes principles experimental details and observation examples for vortices in superconductors the magnetic domain structure in ferromagnets and for fundamental phenomena of quantum mechanics Electron Holography Akira Tonomura,2013-11-11 After examining the fundamentals of electron holography and its applications to the aforementioned fields a detailed discussion of the Aharonov Bohm effect and related experiments is presented Many photographs and illustrations are included to elucidate the text **Introduction to Electron Holography** Edgar Völkl,David C. Joy,1999

This text offers experienced and novice holographers a solid foundation in the theory and practice of holography the next generation of imaging technology The guide s how to aspects enable readers to learn hologram acquisition at the microscope and processing of holograms at the computer as well as digital imaging techniques A useful bibliography on electron holography and applications of the method to problems in materials science physics and the life sciences complete the study

Electron Holography Akira Tonomura,1995 Electron holography is a very powerful technique which uses the phase information in the electron image to study fundamental physics of matter at the micrometer to nanometer scale or even to Angstrom scale A few years ago successful examples of electron holography included confirmation of Aharonov Bohm AB effect and direct visualization of magnetic fields not only outside but also inside of magnetic materials Since then fields of application of electron holography have expanded from solid state physics to materials science and the biological sciences and new techniques have been invented including real time holography and computed tomography of the reconstructed phase image Containing contributions from electron holography experts this book is therefore a unique review of recent developments and future prospects presented by the innovators in this field The chapters cover a wide area of application fields and new techniques magnetic fluxes vortices in superconductors magnetic domains magnetic and electric microfields and p n junctions catalysts biological filaments fine particles and fullerenes for materials applications Chapters are also included on digital recording and processing real time electron holography computed tomography and STEM holography

Electron Holography for Electromagnetic Materials Daisuke Shindo,Zentaro Akase,2024-08-30 This book discusses the direct imaging of electric and magnetic fields of various functional materials using electron holography providing indispensable information for understanding their electromagnetic properties In order to clearly demonstrate the principles of this cutting edge technology easy to understand explanations are accompanied by numerous illustrations and figures throughout the book The book highlights the dynamic nature of electromagnetic fields in novel materials as revealed by changing temperature or applying electric current and magnetic fields Furthermore it showcases as a new development of the technique the direct observation of accumulation and collective motion of electrons around charged insulators Clear

experimental data on electromagnetic fields and the motions of electrons help the reader understand their importance in materials science and fundamental physics Seeing is believing *Multiferroics* Andres Cano,Dennis Meier,Morgan Trassin,2021-06-21 Multiferroics materials with a coexistence of magnetic and ferroelectric order provide an efficient route for the control of magnetism by electric fields The authors cover multiferroic thin film heterostructures device architectures and domain interface effects They critically discuss achievements as well as limitations and assess opportunities for future applications Introduction to Electron Holography Edgar Völkl, Lawrence F. Allard, David C. Joy, 2012-10-23 Experienced and novice holographers receive a solid foundation in the theory and practice of holography the next generation of imaging technology in this superb text The book s how to aspects enable readers to learn hologram acquisition at the microscope and processing of holograms at the computer as well as digital imaging techniques A complete bibliography on electron holography and applications of the method to problems in materials science physics and the life sciences round out the volume s coverage Material Characterization Using Electron Holography Daisuke Shindo, Takeshi Tomita, 2022-10-17 Material Characterization using Electron Holography Exploration of a unique technique that offers exciting possibilities to analyze electromagnetic behavior of materials Material Characterization using Electron Holography addresses how the electromagnetic field can be directly visualized and precisely interpreted based on Maxwell s equations formulated by special relativity leading to the understanding of electromagnetic properties of advanced materials and devices In doing so it delivers a unique route to imaging materials in higher resolution The focus of the book is on in situ observation of electromagnetic fields of diverse functional materials Furthermore an extension of electron holographic techniques such as direct observation of accumulation and collective motions of electrons around the charged insulators is also explained This approach enables the reader to develop a deeper understanding of functionalities of advanced materials Written by two highly qualified authors with extensive first hand experience in the field Material Characterization using Electron Holography covers topics such as Importance of electromagnetic fields and their visualization Maxwell s equations formulated by special relativity and de Broglie waves and wave functions Outlines of general relativity and Einstein s equations principles of electron holography and related techniques Simulation of holograms and visualized electromagnetic fields electric field analysis and in situ observation of electric fields Interaction between electrons and charged specimen surfaces and interpretation of visualization of collective motions of electrons For materials scientists analytical chemists structural chemists analytical research institutes applied physicists physicists semiconductor physicists and libraries looking to be on the cutting edge of methods to analyze electromagnetic behavior of materials Material Characterization using Electron Holography offers comprehensive coverage of the subject from authoritative and forward thinking topical experts Electron Microscopy I - Proceedings Of The 5th Asia-Pacific Electron Microscopy Conference Z H Zhai, Ke-hsin Kuo, 1992-07-15 This unique one volume handbook provides a quick and concise reference guide for practising

ophthalmologists retinal specialists vitreo retinal fellows ophthalmology residents and optometrists on the latest recommendations for managing common vitreo retinal disorders seen in everyday retina practise It provides comprehensive and essential information on diagnosis and management in outline and table format for conciseness and quick access Color illustrations of important clinical manifestations are provided in an appendix Dr Susanna Park is a Professor of ophthalmology and Director of Vitreo retinal Fellowship and Ocular Oncology at the University of California Davis Eye Center She has over 20 years clinical experience as a vitreo retinal specialist and published over 100 journal papers and book chapters on the subject *Springer Handbook of Microscopy* Peter W. Hawkes, John C.H. Spence, 2019-11-02 This book features reviews by leading experts on the methods and applications of modern forms of microscopy The recent awards of Nobel Prizes awarded for super resolution optical microscopy and cryo electron microscopy have demonstrated the rich scientific opportunities for research in novel microscopies Earlier Nobel Prizes for electron microscopy the instrument itself and applications to biology scanning probe microscopy and holography are a reminder of the central role of microscopy in modern science from the study of nanostructures in materials science physics and chemistry to structural biology Separate chapters are devoted to confocal fluorescent and related novel optical microscopies coherent diffractive imaging scanning probe microscopy transmission electron microscopy in all its modes from aberration corrected and analytical to in situ and time resolved low energy electron microscopy photoelectron microscopy cryo electron microscopy in biology and also ion microscopy In addition to serving as an essential reference for researchers and teachers in the fields such as materials science condensed matter physics solid state chemistry structural biology and the molecular sciences generally the Springer Handbook of Microscopy is a unified coherent and pedagogically attractive text for advanced students who need an authoritative yet accessible guide to the science and practice of microscopy **Magnetic Imaging and Its Applications**

to Materials, 2000-10-19 Volume 36 provides an extensive introduction to magnetic imaging including theory and practice utilizing a wide range of magnetic sensitive imaging methods It also illustrates the applications of these modern experimental techniques together with imaging calculations to today s advanced magnetic materials This book is geared towards the upper level undergraduate students and entry level graduate students majoring in physics or materials science who are interested in magnetic structure and magnetic imaging Researchers involved in studying magnetic materials should also find the book useful as it consistently summarizes the recent progress in this field The book covers today s most advanced magnetic imaging techniques comprehensively written with about 150 figures and more than 300 references to the scientific literature

Magnetic Microscopy of Nanostructures Herbert Hopster, Hans Peter Oepen, 2006-03-30 A comprehensive collection of overview articles on novel microscopy methods for imaging magnetic structures on the nanoscale Written by leading scientists in the field the book covers synchrotron based methods spin polarized electron methods and scanning probe techniques It constitutes a valuable source of reference for graduate students and newcomers to the field **Physics and**

Engineering Applications of Magnetism Yoshikazu Ishikawa, Noboru Miura, 2012-12-06 This book was originally published in Japanese in honour of Professor S Chikazumi on the occasion of his retirement from the University of Tokyo in March 1982. Physicists who had been supervised by him or had closely collaborated with him wrote articles on recent developments in magnetism and its engineering applications. In the preface of his excellent textbook *Physics of Magnetism* Wiley 1964 Professor Chikazumi says that recent research in magnetism deals with fundamental physical problems and at the same time with more secondary magnetic phenomena as well as with engineering applications of magnetic materials to electromagnetic machines, permanent magnets and electronic computers and that the purpose of his textbook is to give a general view of these magnetic phenomena focusing its main interest at the center of such a broad field. Always keeping such a viewpoint in mind Professor Chikazumi has contributed a great deal to both fundamental physics and applications of magnetism. This is described in Chap 1 of this book. Many books have been published on both the physics and applications of magnetism. However no single book has a viewpoint covering both of them. The recent development of high technology needs such a broad viewpoint for scientists and engineers since it is a product of both fundamental science and technology. Research in magnetism is based on the response which materials show to the application of magnetic fields.

In Memory of Akira Tonomura K. Fujikawa, 2014 This memorial volume in honor of Dr Akira Tonomura is to commemorate his enormous contributions to fundamental physics in addition to the basic technology of electron microscopy. Dr Tonomura passed away on May 2 2012 at the age of 70. He was Fellow of Hitachi Ltd Group Director of Single Quantum Dynamics Research Group of RIKEN Principal Investigator of the FIRST Tonomura Project and Professor of Okinawa Institute of Science and Technology Graduate University. The book consists of 1 contribution from distinguished physicists who participated in the OC Tonomura FIRST International Symposium on Electron Microscopy and Gauge Fields OCO planned by Tonomura himself and held in Tokyo on May 9 OCo10 2012 and 2 reprints of key papers by Tonomura and his team. Invited speakers at this Symposium include Chen Ning Yang and other distinguished physicists such as Yakir Aharonov Gordon Baym Christian Colliex Anthony J Leggett Naoto Nagaosa Nobuyuki Osakabe and Masahito Ueda. This OC memorial OCO Symposium was originally planned to commemorate the start of the Japanese government sponsored FIRST Tonomura Project to construct the 1.2 MV holography electron microscope capable of observing quantum phenomena in the microscopic world. In addition the book includes contributions from participants of the past ISQM Tokyo symposia held at Hitachi and from Tonomura's longtime friends including Michael Berry Jerome Friedman Hidetoshi Fukuyama Joseph Imry Yoshinori Tokura Jaw Shen Tsai and Anton Zeilinger. The co editors are Kazuo Fujikawa Tonomura's longtime friend and Yoshimasa A Ono who is Tonomura's associate at Hitachi Advanced Research Laboratory and now in the FIRST Tonomura Project. Contents: My Dream of Ultimate Holography Electron Microscope; Akira Tonomura Biography of Akira Tonomura April 1942 OCo May 2012; Nobuyuki Osakabe Tonomura FIRST International Symposium on OC Electron Microscopy and Gauge Fields OCO; Yoshimasa A Ono Recollections.

of Akira Tonomura Thank You and Farewell to Tonomura kun Hidetoshi Fukuyama Remembering Akira Tonomura Michael Berry Akira Tonomura An Experimental Visionary Anton Zeilinger Dr Akira Tonomura Master of Experimental Physics Kazuo Fujikawa Gauge Theory and Aharonov Bohm Effect Topology and Gauge Theory in Physics Chen Ning Yang On the Aharonov Bohm Effect and Why Heisenberg Captures Nonlocality Better Than Schrödinger Yakir Aharonov How the Test of Aharonov Bohm Effect was Initiated at Hitachi Laboratory Nobuyuki Osakabe Some Reflections Concerning Geometrical Phases Anthony J Leggett and Yiruo Lin Mesoscopic Aharonov Bohm Interferometers Decoherence and Thermoelectric Transport Ora Entin Wohlman Amnon Aharony and Yoseph Imry Spin Textures and Gauge Fields in Frustrated Magnets Naoto Nagaosa and Yoshinori Tokura Gauge Theory and Artificial Spin Ices Imaging Emergent Monopoles with Electron Microscopy Shawn D Pollard and Yimei Zhu Do Dispersionless Forces Exist Herman Batelaan and Scot McGregor Aharonov Bohm Effect and Geometric Phases OCo Exact and Approximate Topology Kazuo Fujikawa A Brief Overview and Topological Aspects of Gaseous Bose Einstein Condensates Masahito Ueda Application of Electron Microscopy to Quantum Mechanics and Materials Sciences Mapping Electric Fields with Inelastic Electrons in a Transmission Electron Microscope Christian Colliex OC The Picture is My LifeOCO Shuji Hasegawa Direct Observation of Electronically Phase Separated Charge Density Waves in Lu₂Ir₃Si₅ by Transmission Electron Microscopy Cheng Hsuan Chen Basic Discoveries in Electromagnetic Field Visualization Daisuke Shindo Nanomagnetism Visualized by Electron Holography Hyun Soon Park Quantum Physics Probing the Proton with Electron Microscopy Jerome I Friedman Hanbury BrownOCOTwiss Interferometry with Electrons Coulomb vs Quantum Statistics Gordon Baym and Kan Shen Vortex Molecules in Thin Films of Layered Superconductors Alexander I Buzdin Coherent Quantum Phase Slip Jaw Shen Tsai Coherency of Spin Precession in Metallic Lateral Spin Valves YoshiChika Otani Hiroshi Idzuchi and Yasuhiro Fukuma Transverse Relativistic Effects in Paraxial Wave Interference Konstantin Y Bliokh Yana V Izdebskaya and Franco Nori Readership Graduate students and researchers in physics materials science and related fields

Progress in Optics, 1986-10-01 Progress in Optics is a well established series of volumes of review articles dealing with theoretical and applied optics and related subjects Widely acclaimed by numerous reviewers as representing an authoritative and up to date source of information in all branches of optics the series continues to fulfil a genuine need within the scientific community Articles are contributed by leading scientists including two Nobel Prize winners chosen by the Editor with the advice of an international panel of experts constituting the Editorial Advisory Board Many of the articles appearing in these volumes have since been established as basic references in their respective fields *Fundamentals of Picoscience* Klaus D. Sattler, 2013-09-26 Now ubiquitous in public discussions about cutting edge science and technology nanoscience has generated many advances and inventions from the development of new quantum mechanical methods to far reaching applications in electronics and medical diagnostics Ushering in the next technological era Fundamentals of Picoscience focuses on the instrumentation and experiments emerging at the picometer scale One picometer is the length of a trillionth of

a meter Compared to a human cell of typically ten microns this is roughly ten million times smaller In this state of the art book international scientists and researchers at the forefront of the field present the materials and methods used at the picoscale They address the key challenges in developing new instrumentation and techniques to visualize and measure structures at this sub nanometer level With numerous figures the book will help you Understand how picoscience is an extension of nanoscience Determine which experimental technique to use in your research Connect basic studies to the development of next generation picoelectronic devices The book covers various approaches for detecting characterizing and imaging at the picoscale It then presents picoscale methods ranging from scanning tunneling microscopy STM to spectroscopic approaches at sub nanometer spatial and energy resolutions It also covers novel picoscale structures and picometer positioning systems The book concludes with picoscale device applications including single molecule electronics and optical computers Introductions in each chapter explain basic concepts define technical terms and give context to the main material

Markov Processes and Quantum Theory Masao Nagasawa, 2021-06-23 This book discusses quantum theory as the theory of random Brownian motion of small particles electrons etc under external forces Implying that the Schrödinger equation is a complex valued evolution equation and the Schrödinger function is a complex valued evolution function important applications are given Readers will learn about new mathematical methods theory of stochastic processes in solving problems of quantum phenomena Readers will also learn how to handle stochastic processes in analyzing physical phenomena

Elastic and Inelastic Scattering in Electron Diffraction and Imaging Zhong-lin Wang, 2013-06-29 Elastic and inelastic scattering in transmission electron microscopy TEM are important research subjects For a long time I have wished to systematically summarize various dynamic theories associated with quantitative electron microscopy and their applications in simulations of electron diffraction patterns and images This wish now becomes reality The aim of this book is to explore the physics in electron diffraction and imaging and related applications for materials characterizations Particular emphasis is placed on diffraction and imaging of inelastically scattered electrons which I believe have not been discussed extensively in existing books This book assumes that readers have some preknowledge of electron microscopy electron diffraction and quantum mechanics I anticipate that this book will be a guide to approaching phenomena observed in electron microscopy from the prospects of diffraction physics The SI units are employed throughout the book except for angstrom Å which is used occasionally for convenience To reduce the number of symbols used the Fourier transform of a real space function $P(r)$ for example is denoted by the same symbol $P(u)$ in reciprocal space except that r is replaced by u Upper and lower limits of an integral in the book are co co unless otherwise specified The co co integral limits are usually omitted in a mathematical expression for simplification I very much appreciate opportunity of working with Drs J M Cowley and J C H Spence Arizona State University

Handbook of Nanoscopy Gustaaf van Tendeloo, Dirk van Dyck, Stephen J. Pennycook, 2012-12-21 This completely revised successor to the Handbook of Microscopy supplies in depth coverage of all

imaging technologies from the optical to the electron and scanning techniques Adopting a twofold approach the book firstly presents the various technologies as such before going on to cover the materials class by class analyzing how the different imaging methods can be successfully applied It covers the latest developments in techniques such as in situ TEM 3D imaging in TEM and SEM as well as a broad range of material types including metals alloys ceramics polymers semiconductors minerals quasicrystals amorphous solids among others The volumes are divided between methods and applications making this both a reliable reference and handbook for chemists physicists biologists materials scientists and engineers as well as graduate students and their lecturers

In-situ Materials Characterization Alexander Ziegler, Heinz Graafsma, Xiao Feng Zhang, Joost W.M. Frenken, 2014-04-01 The behavior of nanoscale materials can change rapidly with time either because the environment changes rapidly or because the influence of the environment propagates quickly across the intrinsically small dimensions of nanoscale materials Extremely fast time resolution studies using X rays electrons and neutrons are of very high interest to many researchers and is a fast evolving and interesting field for the study of dynamic processes Therefore in situ structural characterization and measurements of structure property relationships covering several decades of length and time scales from atoms to millimeters and femtoseconds to hours with high spatial and temporal resolutions are crucially important to understand the synthesis and behavior of multidimensional materials The techniques described in this book will permit access to the real time dynamics of materials surface processes and chemical and biological reactions at various time scales This book provides an interdisciplinary reference for research using in situ techniques to capture the real time structural and property responses of materials to surrounding fields using electron optical and x ray microscopies e g scanning transmission and low energy electron microscopy and scanning probe microscopy or in the scattering realm with x ray neutron and electron diffraction

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