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Charged Particle Optics Theory Applied Charged Particle Optics Applied Charged Particle Optics Optics of Charged Particles Principles of Electron Optics Geometrical Charged-Particle Optics Principles of Electron Optics, Volume 2 Charged Particle Beams Advances in Imaging and Electron Physics Applied Charged Particle Optics Handbook of Charged Particle Optics Optics in Our Time Handbook of Charged Particle Optics The Finite Element Method in Charged Particle Optics Demonstrational Optics Particle Characterization: Light Scattering Methods Principles of Charged Particle Acceleration Geometrical Charged-Particle Optics Particles and Waves in Electron Optics and Microscopy Advances in Imaging and Electron Physics Quantum Mechanics of Charged Particle Beam Optics: Understanding Devices from Electron Microscopes to Particle Accelerators Light Scattering Media Optics Charged Particle Optics Theory Applied Charged Particle Optics Optical Particle Sizing International Demonstrational Optics Quantum Mechanics of Charged Particle Beam Optics: Understanding Devices from Electron Microscopes to Particle Accelerators High-energy Nuclear Optics of Polarized Particles Advances in Imaging and Electron Physics Charged Particle Optics of Magnetic Sector Spectrometers Optics Charged Particle Optics Aspects of Charged Particle Optics Atomic, Molecular, and Optical Physics: Charged Particles Geometrical Charged-Particle Optics Introduction to Charged Particle Optics Charged-particle Optics Introduction to Charged Particle Optics Modern Map Methods in Particle Beam Physics

Optics of Charged Particles describes how charged particles move in the main and fringing fields of magnetic or electrostatic dipoles, quadrupoles, and hexapoles using the same type of formulation and consistent nomenclature throughout. This book not only describes the particle trajectories and beam shapes, but also provides guidelines for designing particle optical instruments. The topics discussed include Gaussian optics and transfer matrices, general relations for the motion of charged particles in electromagnetic fields, and quadrupole lenses. The sector field lenses, charged particle beams and phase space, and particle beams in periodic structures are also elaborated. This text likewise considers the fringing fields, image aberrations, and design of particle spectrometers and beam guide lines. This publication is suitable for undergraduate students in physics and mathematics. With the growing proliferation of nanotechnologies, powerful imaging technologies are being developed to operate at the sub-nanometer scale. The newest edition of a bestseller, the Handbook of Charged Particle Optics, Second Edition provides essential background information for the design and operation of high resolution focused probe instruments. The book’s unique approach covers both the theoretical and practical knowledge of high resolution probe forming instruments. The second edition features new chapters on aberration correction and applications of gas phase field ionization sources. With the inclusion of additional references to past and present work in the field, this second edition offers perfectly calibrated coverage of the field’s cutting-edge technologies with added insight into how they work. Written by the leading research scientists, the second edition of the Handbook of Charged Particle Optics is a complete guide to understanding, designing, and using high resolution probe instrumentation. Advances in Imaging and Electron Physics merges two long-running serials--Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. This series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing, electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. * Contributions from leading international scholars and industry experts * Discusses hot topic areas and presents current and future research trends * Invaluable reference and guide for physicists, engineers and mathematicians Tables include: general trajectory functions; profile curves; and dispersion and transmission functions for symmetrical instruments. Optical particle s1z1ng is undoubtedly a fascinating field of research of the utmost practical importance. In the Universe fluids are nearly everywhere, and when they occur they almost invariably contain particles. Inside our bodies we can take the example of blood transporting a vi tal procession of red and white cells. Around us, we can find various particles in the air we breathe, bubbles in the champagne or the soda we drink, or natural and artificial (polluting!) particles in the lakes we swim in. Industrial processes and systems are also concerned with particles, from pulverized coal flames to fluidized beds, in a range of applications involving rocket exhausts, pneuma tic transport and more generally the infinite realm of mul tiphase situations. Such an obviously vast field would require a whole volume like this one merely to attempt to describe it superficially. To be sure, we would need a scientific Prevert to catalogue such an endless inventory. Finally, even outside our terrestrial spaceship particles can be detected in alien atmospheres or between stars. Theorists will enjoy analyzing the richness of light/particle interact. ion, a subject which is very far from being exhausted. Experimental researchers will love designing and studying various probing instruments with a laser source at the input and a computer at the output, two requisites of today' s technological revolution. Particle characterization is an important component in product research and development, manufacture, and quality control of particulate materials and an important tool in the frontier of sciences, such as in biotechnology and nanotechnology. This book systematically describes one major branch of modern particle characterization technology - the light scattering methods. This is the first monograph in particle science and technology covering the principles, instrumentation, data interpretation, applications, and latest experimental development in laser diffraction, optical particle counting, photon correlation spectroscopy, and electrophoretic light scattering. In addition, a summary of all major particle sizing and other characterization methods, basic statistics and sample preparation techniques used in particle characterization, as well as almost 500 latest references are provided. The book is a must for industrial users of light scattering techniques characterizing a variety of particulate systems and for undergraduate or graduate students who want to learn how to use light scattering to study particular materials, in chemical engineering, material sciences, physical chemistry and other related fields. The resolution of any imaging microscope is ultimately limited by di?raction and can never be signi?cantly smaller than the wavelength ? of the ima- forming wave, as realized by Abbe [1] in 1870. In a visionary statement, he argued that there might be some yet unknown radiation with a shorter wa- length than that of light enabling a higher resolution at some time in the future. The discovery of the electron provided such a radiation because its wavelength at accelerating voltages above 1 kV is smaller than the radius of the hydrogen atom. The wave property of the electron was postulated in 1924 by de Broglie [2]. Geometrical electron optics started in 1926 when Busch [3] demonstrated that the magnetic ?eld of a rotationally symmetric coil acts as a converging lens for electrons. The importance of this discovery was s- sequently conceived by Knoll and Ruska [4] who had the idea to build an electron microscope by combining a sequence of such lenses. Within a short period of time, the resolution of the electron microscope surpassed that of the light microscope, as depicted in Fig. 1. This success resulted primarily from theextremelysmallwavelengthoftheelectronsratherthanfromthequalityof standard electron lenses which limit the attainable resolution to about 100?. Therefore, shortening the wavelength by increasing the voltage was the most convenient method for improving the resolution. However, radiation damage by knock-on displacement of atoms limits severely the application of hi- voltage electron microscopes. Originally published as part of the renowned Bergmann-Schaefer textbook series on experimental physics, this is a revised and extended version of the 9th edition of Volume 3. In it, eminent experimental physicists provide an in-depth treatment of both light and particle optics from a primarily experimental perspective. Each author includes the necessary theoretical framework needed to understand the various phenomena, then introduces readers to the major experimental features. Authoritative and comprehensive, this volume offers a wealth of information and sets the standard by which all similar texts will be judged. Charged Particle Optics Theory: An Introduction identifies the most important concepts of charged particle optics theory, and derives each mathematically from the first principles of physics. Assuming an advanced undergraduate-level understanding of calculus, this book follows a logical progression, with each concept building upon the preceding one. Beginning with a non-mathematical survey of the optical nature of a charged particle beam, the text: Discusses both geometrical and wave optics, as well as the correspondence between them Describes the two-body scattering problem, which is essential to the interaction of a fast charged particle with matter Introduces electron emission as a practical consequence of quantum mechanics Addresses the Fourier transform and the linear second-order differential equation Includes problems to amplify and fill in the theoretical details, with solutions presented separately Charged Particle Optics Theory: An Introduction makes an ideal textbook as well as a convenient reference on the theoretical origins of the optics of charged particle beams. It is intended to prepare the reader to understand the large body of published research in this mature field, with the end result translated immediately to practical application. This authoritative text offers a unified, programmed summary of the principles underlying all charged particle accelerators — it also doubles as a reference collection of equations and material essential to accelerator development and beam applications. The only text that covers linear induction accelerators, the work contains straightforward expositions of basic principles rather than detailed theories of specialized areas. 1986 edition. Advances in Imaging and Electron Physics merges two long-running serials--Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. This series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing, electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. Contributions from leading international scholars and industry experts Discusses hot topic areas and presents current and future research trends Invaluable reference and guide for physicists, engineers and mathematicians Classical Charged Particle Beam Optics used in the design and operation of all present-day charged particle beam devices, from low energy electron microscopes to high energy particle accelerators, is entirely based on classical mechanics. A question of curiosity is: How is classical charged particle beam optics so successful in practice though the particles of the beam, like electrons, are quantum mechanical? Quantum Mechanics of Charged Particle Beam Optics answers this question with a comprehensive formulation of 'Quantum Charged Particle Beam Optics' applicable to any charged particle beam device. The various phenomena caused by refraction and diffraction of polarized elementary particles in matter have opened up a new research area in the particle physics: nuclear optics of polarized particles. Effects similar to the well-known optical phenomena such as birefringence and Faraday effects, exist also in particle physics, though the particle wavelength is much less than the distance between atoms of matter. Current knowledge of the quasi-optical effects, which exist for all particles in any wavelength range (and energies from low to extremely high), will enable us to investigate different properties of interacting particles (nuclei) in a new aspect. This pioneering book will provide detailed accounts of quasi-optical phenomena in the particle polarization, and will interest physicists and professionals in experimental particle physics. The theory of the scattering of light by small particles is very important in a wide range of applications in atmospheric physics and atmospheric optics, ocean optics, remote sensing, astronomy and astrophysics and biological optics. This book summarises current knowledge of the optical properties of single small particles and natural light scattering media such as snow, clouds, foam aerosols etc. The book considers both single and multiple light scattering regimes, together with light scattering and radiative transfer in close-packed media. The third edition incorporates new findings in the area of light scattering media optics in an updated version of the text. Detailed enough to serve as both text and reference, this volume addresses topics vital to understanding high-power accelerators and high-brightness-charged particle beams, including stochastic cooling, high-brightness injectors, and free electron laser. 1990 edition. With this volume, Methods of Experimental Physics becomes Experimental Methods in the Physical Sciences, a name change which reflects the evolution of todays science. This volume is the first of three which will provide a comprehensive treatment of the key experimental methods of atomic, molecular, and optical physics; the three volumes as a set will form an excellent experimental handbook for the field. The wide availability of tunable lasers in the pastseveral years has revolutionized the field and lead to the introduction of many new experimental methods that are covered in these volumes. Traditional methods are also included to ensure that the volumes will be a complete reference source for the field. Demonstrational Optics presents a new didactical approach to the study of optics. Emphasizing the importance of elaborate new experimental demonstrations, pictorial illustrations, computer simulations and models of optical phenomena in order to ensure a deeper understanding of the general and statistical optics. It includes problems focused on the pragmatic needs of students, secondary school teachers, university professors and optical engineers. This volume aims to present improved teaching methods and practical explanations of optical phenomena. An important feature is the inclusion of elaborate pictorial approach to explaining optical phenomena in parallel to a general mathematical description. The modern approach developed here is also used to illustrate many basic phenomena, complimenting the existing literature. The volume contains a valuable compendium of optical experiments for university, college and senior-school physics teachers. Experiments and modern computer simulations are described within the volume in sufficient detail to allow successful reproduction in a classroom or lecture theatre. With the growing proliferation of nanotechnologies, powerful imaging technologies are being developed to operate at the sub-nanometer scale. The newest edition of a bestseller, the Handbook of Charged Particle Optics, Second Edition provides essential background information for the design and operation of high resolution focused probe instruments. The book's unique approach covers both the theoretical and practical knowledge of high resolution probe forming instruments. The second edition features new chapters on aberration correction and applications of gas phase field ionization sources. With the inclusion of additional references to past and present work in the field, this second edition offers perfectly calibrated coverage of the field's cutting-edge technologies with added insight into how they work. 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This resource covering all theoretical aspects of modern geometrical charged-particle optics is aimed at anyone involved in the design of electron optical instruments and beam-guiding systems for charged particles. Principles of Electron Optics: Applied Geometrical Optics, Second Edition gives detailed information about the many optical elements that use the theory presented in Volume 1: electrostatic and magnetic lenses, quadrupoles, cathode-lens-based instruments including the new ultrafast microscopes, low-energy-electron microscopes and photoemission electron microscopes and the mirrors found in their systems, Wien filters and deflectors. The chapter on aberration correction is largely new. The long section on electron guns describes recent theories and covers multi-column systems and carbon nanotube emitters. Monochromators are included in the section on curved-axis systems. The lists of references include many articles that will enable the reader to go deeper into the subjects discussed in the text. The book is intended for postgraduate students and teachers in physics and electron optics, as well as researchers and scientists in academia and industry working in the field of electron optics, electron and ion microscopy and nanolithography. Offers a fully revised and expanded new edition based on the latest research developments in electron optics Written by the top experts in the field Covers every significant advance in electron optics since the subject originated Contains exceptionally complete and carefully selected references and notes Serves both as a reference and text Written by a pioneer in the field, this overview of charged particle optics provides a solid introduction to the subject area for all physicists wishing to design their own apparatus or better understand the instruments with which they work. It begins by introducing electrostatic lenses and fields used for acceleration, focusing and deflection of ions or electrons. Subsequent chapters give detailed descriptions of electrostatic deflection elements, uniform and non-uniform magnetic sector fields, image aberrations, and, finally, fringe field confinement. Demonstrational Optics presents a new didactical approach to the study of optics. Emphasizing the importance of elaborate new experimental demonstrations, pictorial illustrations, computer simulations and models of optical phenomena in order to ensure a deeper understanding of the general and statistical optics. It includes problems focused on the pragmatic needs of students, secondary school teachers, university professors and optical engineers. This volume aims to present improved teaching methods and practical explanations of optical phenomena. An important feature is the inclusion of elaborate pictorial approach to explaining optical phenomena in parallel to a general mathematical description. The modern approach developed here is also used to illustrate many basic phenomena, complimenting the existing literature. The volume contains a valuable compendium of optical experiments for university, college and senior-school physics teachers. Experiments and modern computer simulations are described within the volume in sufficient detail to allow successful reproduction in a classroom or lecture theatre. Light and light based technologies have played an important role in transforming our lives via scientific contributions spanned over thousands of years. In this book we present a vast collection of articles on various aspects of light and its applications in the contemporary world at a popular or semi-popular level. These articles are written by the world authorities in their respective fields. This is therefore a rare volume where the world experts have come together to present the developments in this most important field of science in an almost pedagogical manner. This volume covers five aspects related to light. The first presents two articles, one on the history of the nature of light, and the other on the scientific achievements of Ibn-Haitham (Alhazen), who is broadly considered the father of modern optics. These are then followed by an article on ultrafast phenomena and the invisible world. The third part includes papers on specific sources of light, the discoveries of which have revolutionized optical technologies in our lifetime. They discuss the nature and the characteristics of lasers, Solid-state lighting based on the Light Emitting Diode (LED) technology, and finally modern electron optics and its relationship to the Muslim golden age in science. The book’s fourth part discusses various applications of optics and light in today's world, including biophotonics, art, optical communication, nanotechnology, the eye as an optical instrument, remote sensing, and optics in medicine. In turn, the last part focuses on quantum optics, a modern field that grew out of the interaction of light and matter. Topics addressed include atom optics, slow, stored and stationary light, optical tests of the foundation of physics, quantum mechanical properties of light fields carrying orbital angular momentum, quantum communication, and Wave-Particle dualism in action. Advances in Imaging & Electron Physics merges two long-running serials--Advances in Electronics & Electron Physics and Advances in Optical & Electron Microscopy. The series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing, electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. Classical Charged Particle Beam Optics used in the design and operation of all present-day charged particle beam devices, from low energy electron microscopes to high energy particle accelerators, is entirely based on classical mechanics. A question of curiosity is: How is classical charged particle beam optics so successful in practice though the particles of the beam, like electrons, are quantum mechanical? Quantum Mechanics of Charged Particle Beam Optics answers this question with a comprehensive formulation of ‘Quantum Charged Particle Beam Optics’ applicable to any charged particle beam device. 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Contains contributions from leading authorities on the subject matter Informs and updates all the latest developments in the field of imaging and electron physics Provides practitioners interested in microscopy, optics, image processing, mathematical morphology, electromagnetic fields, electron, and ion emission with a valuable resource Features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science, and digital image processing This second edition is an extended version of the first edition of Geometrical Charged-Particle Optics. The updated reference monograph is intended as a guide for researchers and graduate students who are seeking a comprehensive treatment of the design of instruments and beam-guiding systems of charged particles and their propagation in electromagnetic fields. Wave aspects are included in this edition for explaining electron holography, the Aharanov-Bohm effect and the resolution of electron microscopes limited by diffraction. Several methods for calculating the electromagnetic field are presented and procedures are outlined for calculating the properties of systems with arbitrarily curved axis. Detailed methods are presented for designing and optimizing special components such as aberration correctors, spectrometers, energy filters monochromators, ion traps, electron mirrors and cathode lenses. In particular, the optics of rotationally symmetric lenses, quadrupoles, and systems composed of these elements are discussed extensively. Beam properties such as emittance, brightness, transmissivity and the formation of caustics are outlined. Relativistic motion and spin precession of the electron are treated in a covariant way by introducing the Lorentz-invariant universal time and by extending Hamilton’s principle from three to four spatial dimensions where the laboratory time is considered as the fourth pseudo-spatial coordinate. Using this procedure and introducing the self action of the electron, its accompanying electromagnetic field and its radiation field are calculated for arbitrary motion. In addition, the Stern-Gerlach effect is revisited for atomic and free electrons. In the span of only a few decades, the finite element method has become an important numerical technique for solving problems in the subject of charged particle optics. The situation has now developed up to the point where finite element simulation software is sold commercially and routinely used in industry. The introduction of the finite element method in charged particle optics came by way of a PHD thesis written by Eric Munro at the University of Cambridge, England, in 1971 [1], shortly after the first papers appeared on its use to solve Electrical Engineering problems in the late sixties. Although many papers on the use of the finite element method in charged particle optics have been published since Munro's pioneering work, its development in this area has not as yet appeared in any textbook. This fact must be understood within a broader context. The first textbook on the finite element method in Electrical Engineering was published in 1983 [2]. At present, there are only a handful of other books that describe it in relation to Electrical Engineering topics [3], let alone charged particle optics. This is but a tiny fraction of the books dedicated to the finite element method in other subjects such as Civil Engineering. The motivation to write this book comes from the need to redress this imbalance. There is also another important reason for writing this book.