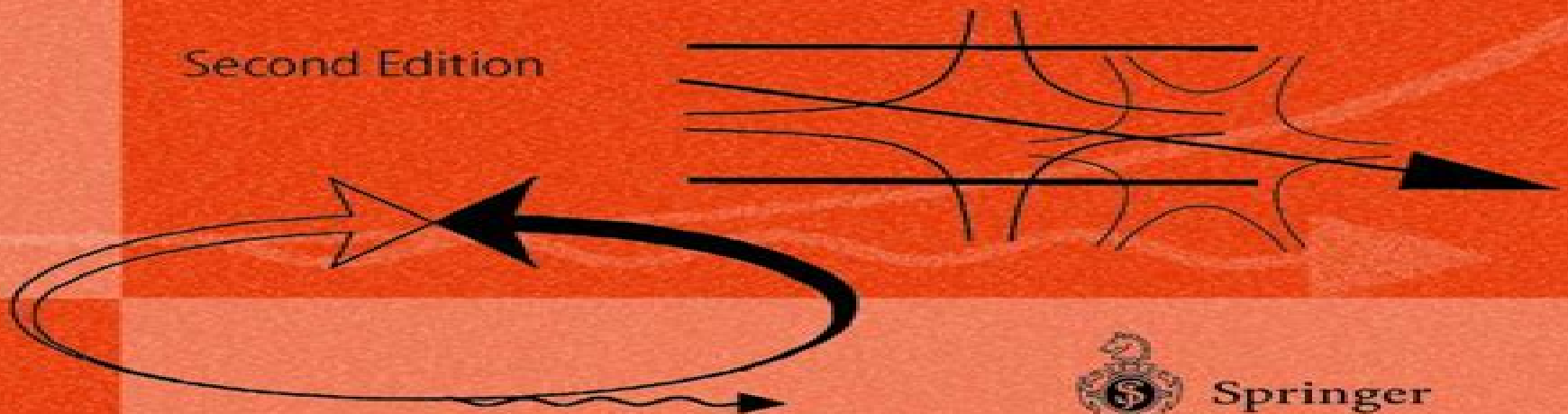


H. Wiedemann

Particle Accelerator Physics I

Basic Principles
and Linear Beam Dynamics

Second Edition



Springer

Particle Accelerator Physics Basic Principles And Linear Beam Dynamics

Helmut Wiedemann



Particle Accelerator Physics Basic Principles And Linear Beam Dynamics:

Particle Accelerator Physics Helmut Wiedemann, 2003 This two volume book serves as a thorough introduction to the field of high energy particle accelerator physics and beam dynamics Volume 1 provides a general understanding of the field and a firm basis for the study of the more elaborate topic mainly nonlinear and higher order beam dynamics which is the subject of Volume 2

Particle Accelerator Physics I Helmut Wiedemann, 1999-03-12 In this second edition of Particle Accelerator Physics Vol 1 is mainly a reprint of the first edition without significant changes in content The bibliography has been updated to include more recent progress in the field of particle accelerators With the help of many observant readers a number of misprints and errors could be eliminated The author would like to express his sincere appreciation to all those who have pointed out such shortcomings and welcome such information and any other relevant information in the future The author would also like to express his special thanks to the editor Dr Helmut Lotsch and his staff for editorial as well as technical advice and support which contributed greatly to the broad acceptance of this text and made a second edition of both volumes necessary Palo Alto California Helmut Wiedemann November 1998 VII Preface to the First Edition The purpose of this textbook is to provide a comprehensive introduction into the physics of particle accelerators and particle beam dynamics Particle accelerators have become important research tools in high energy physics as well as sources of incoherent and coherent radiation from the far infra red to hard x rays for basic and applied research During years of teaching accelerator physics it became clear that the single most annoying obstacle to get introduced into the field is the absence of a suitable textbook

Particle Accelerator Physics Helmut Wiedemann, 2013-11-11 Particle Accelerator Physics is designed to serve as an introduction to the field of high energy particle accelerator physics and particle beam dynamics It covers the dynamics of relativistic particle beams basics of particle guidance and focusing lattice design characteristics of beam transport systems and circular accelerators Particle beam optics is treated in the linear approximation including sextupoles to correct for chromatic aberrations Perturbations to linear beam dynamics are analyzed in detail and correction measures are discussed Basic lattice design features and building blocks leading to the design of more complicated beam transport systems and circular accelerators are studied Characteristics of synchrotron radiation and quantum effects due to the statistical emission of photons on particle trajectories are derived and applied to determine particle beam parameters The discussions specifically concentrate on relativistic particle beams and the physics of beam optics in beam transport systems and circular accelerators such as synchrotrons and storage rings This book is aimed at students and scientists who are interested in an introduction to particle beam optics and accelerator physics It provides a general understanding of particle beam physics and forms a broad basis for further more detailed studies of nonlinear beam dynamics and associated accelerator physics problems to be discussed in a subsequent volume

Particle Accelerator Physics II Helmut Wiedemann, 2012-12-06 This text is a continuation of the first volume of Particle Accelerator Physics on Basic Principles and

Linear Beam Dynamics While the first volume was written as an introductory overview into beam dynamics it does not include more detailed discussion of nonlinear and higher order beam dynamics or the full theory of synchrotron radiation from relativistic electron beams Both issues are however of fundamental importance for the design of modern particle accelerators In this volume beam dynamics is formulated within the realm of Hamiltonian dynamics leading to the description of multiparticle beam dynamics with the Vlasov equation and including statistical processes with the Fokker Planck equation Higher order perturbations and aberrations are discussed in detail including Hamiltonian resonance theory and higher order beam dynamics The discussion of linear beam dynamics in Vol I is completed here with the derivation of the general equation of motion including kinematic terms and coupled motion To build on the theory of longitudinal motion in Vol I the interaction of a particle beam with the rf system including beam loading higher order phase focusing and the combination of acceleration and transverse focusing is discussed The emission of synchrotron radiation greatly affects the beam quality of electron or positron beams and we therefore derive the detailed theory of synchrotron radiation including spatial and spectral distribution as well as properties of polarization

Particle Accelerator Physics II H.

Wiedemann, 2012-12-06 Particle Accelerator Physics II continues the discussion of particle accelerator physics beyond the introductory Particle Accelerator Physics I Aimed at students and scientists who plan to work or are working in the field of accelerator physics Basic principles of beam dynamics already discussed in Vol I are expanded into the nonlinear regime in order to tackle fundamental problems encountered in present day accelerator design and development Nonlinear dynamics is discussed both for the transverse phase space to determine chromatic and geometric aberrations which limit the dynamic aperture as well as for the longitudinal phase space in connection with phase focusing at very small values of the momentum compaction Effects derived theoretically are compared with observations made at existing accelerators

Particle Accelerator Physics I Helmut Wiedemann, 2012-12-06 In this second edition of Particle Accelerator Physics Vol 1 is mainly a reprint of the first edition without significant changes in content The bibliography has been updated to include more recent progress in the field of particle accelerators With the help of many observant readers a number of misprints and errors could be eliminated The author would like to express his sincere appreciation to all those who have pointed out such shortcomings and welcome such information and any other relevant information in the future The author would also like to express his special thanks to the editor Dr Helmut Lotsch and his staff for editorial as well as technical advice and support which contributed greatly to the broad acceptance of this text and made a second edition of both volumes necessary Palo Alto California Helmut Wiedemann November 1998 VII Preface to the First Edition The purpose of this textbook is to provide a comprehensive introduction into the physics of particle accelerators and particle beam dynamics Particle accelerators have become important research tools in high energy physics as well as sources of incoherent and coherent radiation from the far infra red to hard x rays for basic and applied research During years of teaching accelerator physics it became clear that the

single most annoying obstacle to get introduced into the field is the absence of a suitable textbook *Accelerator Physics (Fourth Edition)* Shyh-yuan Lee, 2018-11-15 Research and development of high energy accelerators began in 1911 Since then progresses achieved are The impacts of the accelerator development are evidenced by the many ground breaking discoveries in particle and nuclear physics atomic and molecular physics condensed matter physics biology biomedical physics nuclear medicine medical therapy and industrial processing This book is intended to be used as a graduate or senior undergraduate textbook in accelerator physics and science It can be used as preparatory course material in graduate accelerator physics thesis research The text covers historical accelerator development transverse betatron motion synchrotron motion an introduction to linear accelerators and synchrotron radiation phenomena in low emittance electron storage rings introduction to special topics such as the free electron laser and the beam beam interaction Hamiltonian dynamics is used to understand beam manipulation instability and nonlinearity Each section is followed by exercises which are designed to reinforce the concept discussed and to solve a realistic accelerator design problem Particle Accelerator Physics Helmut Wiedemann, 2015-07-24 This book by Helmut Wiedemann is a well established classic text providing an in depth and comprehensive introduction to the field of high energy particle acceleration and beam dynamics The present 4th edition has been significantly revised updated and expanded The newly conceived Part I is an elementary introduction to the subject matter for undergraduate students Part II gathers the basic tools in preparation of a more advanced treatment summarizing the essentials of electrostatics and electrodynamics as well as of particle dynamics in electromagnetic fields Part III is an extensive primer in beam dynamics followed in Part IV by an introduction and description of the main beam parameters and including a new chapter on beam emittance and lattice design Part V is devoted to the treatment of perturbations in beam dynamics Part VI then discusses the details of charged particle acceleration Parts VII and VIII introduce the more advanced topics of coupled beam dynamics and describe very intense beams a number of additional beam instabilities are introduced and reviewed in this new edition Part IX is an exhaustive treatment of radiation from accelerated charges and introduces important sources of coherent radiation such as synchrotrons and free electron lasers The appendices at the end of the book gather useful mathematical and physical formulae parameters and units Solutions to many end of chapter problems are given This textbook is suitable for an intensive two semester course starting at the senior undergraduate level **Beam Dynamics In High Energy Particle Accelerators** Andrzej Wolski, 2014-01-21 Particle accelerators are essential tools for scientific research in fields as diverse as high energy physics materials science and structural biology They are also widely used in industry and medicine Producing the optimum design and achieving the best performance for an accelerator depends on a detailed understanding of many often complex and sometimes subtle effects that determine the properties and behavior of the particle beam Beam Dynamics in High Energy Particle Accelerators provides an introduction to the concepts underlying accelerator beam line design and analysis taking an approach that emphasizes the elegance of the subject and

leads into the development of a range of powerful techniques for understanding and modeling charged particle beams

Techniques and Concepts of High-Energy Physics Harrison B. Prosper, Michael Danilov, 2001-11-27 The eleventh Advanced Study Institute ASI on Techniques and Concepts of High Energy Physics marks the transition from an extraordinary century of science to one that will surely bring wonders we can scarcely imagine. It also marks a transition from its founder, the inimitable Tom Ferbel, to its new directors. We are honored to have been asked to continue the venerable tradition that Tom established. The school is his distinctive creation and will always bear his mark. The 2000 meeting was held at the Hotel on the Cay in St. Croix. It is an ideal location sufficiently secluded to inspire a vigorous but informal intellectual atmosphere yet close enough to the main island to afford opportunities to mingle with the locals and partake of their hospitality. Altogether 76 physicists, both young and not so young, participated from 18 countries. For the first time, this meeting attracted a substantial number of students from Eastern Europe, all of whom were warmly welcomed. The bulk of the financial support for the meeting was provided by the Scientific Affairs Division of the North Atlantic Treaty Organization (NATO). The ASI was co-sponsored by the U.S. Department of Energy (DOE) by the Fermi National Accelerator Laboratory (Fermilab) by the U.S. National Science Foundation (NSF) the University of Rochester, Florida State University (FSU) and the Institute for Theoretical and Experimental Physics (ITEP) Moscow. As is the tradition, the scientific program was designed for advanced graduate students and recent PhD recipients in experimental particle physics. The present volume covers topics that update and complement those published by Plenum and Kluwer for the first ten ASIs. The material in this volume should be of interest to a wide audience of physicists.

Physics of Particle Accelerators

Margaret Dienes, 1989 **Beam-Wave Interaction in Periodic and Quasi-Periodic Structures** Levi

Schächter, 2013-03-09 During the past seven years I have been involved in the investigation of high power microwave sources for accelerator and radar applications. As for many others before me, the starting point of this book was a collection of notes on theoretical topics out of the material I had been working on. The notes were the core of a course for graduate students at Cornell University. When I started to prepare these notes, it seemed a fairly straightforward and not very time-consuming task since I had most of the material well organized. Today, three years after the preparation of the first notes, I can only wonder how naive this thought was. Most of my work was oriented towards analytic and quasi-analytic techniques for the investigation of the interaction of an electron beam with electromagnetic waves. These topics are presented in Chaps 4 and 6. However, for a systematic elaboration of these topics, it was necessary to provide some general background; therefore, parts of what are today Chaps 2, 3, and 5 were prepared. Related topics of acceleration concepts were also prepared to some extent, but I ran out of time and the material. Chap 8 was not delivered. In the meantime, various sections of this book were taught at the Technion-Israel Institute of Technology and Ben-Gurion University. In the last version, I included a discussion on free electron lasers. Chap 7 **Ultrafast Optics** IV Ferenc Krausz, Georg Korn, Paul Corkum, Ian A. Walmsley, 2012-08-10 The

papers in this volume cover the major areas of research activity in the field of ultrafast optics at the present time and they have been selected to provide an overview of the current state of the art. The purview of the field is the methods for the generation, amplification and characterization of electromagnetic pulses with durations from the pico to the attosecond range as well as the technical issues surrounding the application of these pulses in physics, chemistry and biology. The contributions were solicited from the participants in the Ultrafast Optics IV Conference held in Vienna, Austria, in June 2003. The purpose of the conference is similar to that of this book to provide a forum for the latest advances in ultrafast optical technology. Ultrafast light sources provide a means to observe and manipulate events on the scale of atomic and molecular dynamics. This is possible either through appropriate shaping of the time-dependent electric field or through the application of fields whose strength is comparable to the binding forces of the electrons in atoms and molecules. Recent advances discussed here include the generation of pulses shorter than two optical cycles and the ability to measure and to shape them in all degrees of freedom with unprecedented precision and to amplify them to the Zettawatt/cm range.

EPAC 96 S. Myers, 1996-01-01 EPAC 96 Proceedings of the Fifth European Particle Accelerator Conference, Sitges, Barcelona, 10 to 14 June 1996. Three Volume Set also available on a CD-ROM provides a comprehensive overview of research technology and special applications in the field of accelerators. It serves as a source for novel ideas and familiarizes researchers with advanced concepts.

Physics Of Intense Charged Particle Beams In High Energy Accelerators Ronald C Davidson, Qin Hong, 2001-10-22. *Physics of Intense Charged Particle Beams in High Energy Accelerators* is a graduate level text complete with 75 assigned problems which covers a broad range of topics related to the fundamental properties of collective processes and nonlinear dynamics of intense charged particle beams in periodic focusing accelerators and transport systems. The subject matter is treated systematically from first principles using a unified theoretical approach and the emphasis is on the development of basic concepts that illustrate the underlying physical processes in circumstances where intense self-fields play a major role in determining the evolution of the system. The theoretical analysis includes the full influence of dc space charge and intense self-field effects on detailed equilibrium stability and transport properties and is valid over a wide range of system parameters ranging from moderate intensity moderate emittance beams to very high intensity low emittance beams. This is particularly important at the high beam intensities envisioned for present and next generation accelerators, colliders and transport systems for high energy and nuclear physics applications and for heavy ion fusion. The statistical models used to describe the properties of intense charged particle beams are based on the Vlasov-Maxwell equations, the macroscopic fluid-Maxwell equations or the Klimontovich-Maxwell equations as appropriate and extensive use is made of theoretical techniques developed in the description of one-component nonneutral plasmas and multispecies electrically neutral plasmas as well as established techniques in accelerator physics, classical mechanics, electrodynamics and statistical physics. *Physics of Intense Charged Particle Beams in High Energy Accelerators* emphasizes basic physics principles and the

thorough presentation style is intended to have a lasting appeal to graduate students and researchers alike Because of the advanced theoretical techniques developed for describing one component charged particle systems a useful companion volume to this book is Physics of Nonneutral Plasmas by Ronald C Davidson a **Synchrotron Radiation Sources - A Primer** Herman Winick,1995-02-28 Specialists in the technical components of a synchrotron light source are usually well versed in their field and in the associated technical literature However with the rapid and continuing growth of synchrotron radiation research and with new facilities coming online and being authorized for design and construction around the world there is a need for a reference book that describes the various technical components of a synchrotron light source in a manner that will be useful to those who lack specialized technical background but who have responsibility for some part of the design construction operation or development of such a facility This would include technicians engineers and physicists who have technical background in related fields but no specific experience with a synchrotron light source and also project managers laboratory directors and government officials involved with synchrotron light facilities College level scientific or engineering training or the equivalent experience is assumed and appropriate mathematics is used throughout However the basic concepts in each chapter are given in less technical language and a glossary of terms as well as an index will make the book useful for those with less technical training or experience **X-Ray Spectroscopy with Synchrotron Radiation** Stephen P. Cramer,2020-11-19 Synchrotron radiation has been a revolutionary and invaluable research tool for a wide range of scientists including chemists biologists physicists materials scientists geophysicists It has also found multidisciplinary applications with problems ranging from archeology through cultural heritage to paleontology The subject of this book is x ray spectroscopy using synchrotron radiation and the target audience is both current and potential users of synchrotron facilities The first half of the book introduces readers to the fundamentals of storage ring operations the qualities of the synchrotron radiation produced the x ray optics required to transport this radiation and the detectors used for measurements The second half of the book describes the important spectroscopic techniques that use synchrotron x rays including chapters on x ray absorption x ray fluorescence resonant and non resonant inelastic x ray scattering nuclear spectroscopies and x ray photoemission A final chapter surveys the exciting developments of free electron laser sources which promise a second revolution in x ray science Thanks to the detailed descriptions in the book prospective users will be able to quickly begin working with these techniques Experienced users will find useful summaries key equations and exhaustive references to key papers in the field as well as outlines of the historical developments in the field Along with plentiful illustrations this work includes access to supplemental Mathematica notebooks which can be used for some of the more complex calculations and as a teaching aid This book should appeal to graduate students postdoctoral researchers and senior scientists alike

Accelerator Physics Shyh-Yuan Lee,2004 The development of high energy accelerators began in 1911 when Rutherford discovered the atomic nuclei inside the atom Since then progress has been made in the following 1 development of high

voltage dc and rf accelerators 2 achievement of high field magnets with excellent field quality 3 discovery of transverse and longitudinal beam focusing principles 4 invention of high power rf sources 5 improvement of high vacuum technology 6 attainment of high brightness polarized unpolarized electron ion sources 7 advancement of beam dynamics and beam manipulation schemes such as beam injection accumulation slow and fast extraction beam damping and beam cooling instability feedback etc The impacts of the accelerator development are evidenced by the many ground breaking discoveries in particle and nuclear physics atomic and molecular physics condensed matter physics biomedical physics medicine biology and industrial processing This book is intended to be used as a graduate or senior undergraduate textbook in accelerator physics and science It can be used as preparatory course material for graduate accelerator physics students doing thesis research The text covers historical accelerator development transverse betatron motion synchrotron motion an introduction to linear accelerators and synchrotron radiation phenomena in low emittance electron storage rings introduction to special topics such as the free electron laser and the beam beam interaction Attention is paid to derivation of the action angle variables of the phase space because the transformation is important for understanding advanced topics such as the collective instability and nonlinear beam dynamics Each section is followed by exercises which are designed to reinforce the concept discussed and to solve a realistic accelerator design problem

Measurement and Control of Charged Particle Beams Michiko G. Minty, Frank Zimmermann, 2013-03-09 The intent of this book is to bridge the link between experimental observations and theoretical principles in accelerator physics The methods and concepts taken primarily from high energy accelerators have for the most part already been presented in internal reports and proceedings of accelerator conferences a portion of which has appeared in refereed journals In this book we have tried to coherently organize this material so as to be useful to designers and operators in the commissioning and operation of particle accelerators A point of emphasis has been to provide wherever possible experimental data to illustrate the particular concept under discussion Of the data presented most are collected from presently existing or past accelerators and we regret the problem of providing original data some of which appear in less accessible publications for possible omissions we apologize Regarding the uniformity of the text particularly with respect to symbol definitions we have taken the liberty to edit certain representations of the data while trying to maintain the essence of the presented observations Throughout the text we have attempted to provide references which are readily available for the reader

Accelerator Physics S Y Lee, 2011-11-16 Research and development of high energy accelerators began in 1911 Since then milestones achieved are 1 development of high gradient dc and rf accelerators 2 achievement of high field magnets with excellent field quality 3 discovery of transverse and longitudinal beam focusing principles 4 invention of high power rf sources 5 improvement of ultra high vacuum technology 6 attainment of high brightness polarized unpolarized electron ion sources 7 advancement of beam dynamics and beam manipulation schemes such as beam injection accumulation slow and fast extraction beam damping and beam cooling instability feedback laser

beam interaction and harvesting instability for high brilliance coherent photon source The impacts of the accelerator development are evidenced by the many ground breaking discoveries in particle and nuclear physics atomic and molecular physics condensed matter physics biology biomedical physics nuclear medicine medical therapy and industrial processing This book is intended to be used as a graduate or senior undergraduate textbook in accelerator physics and science It can be used as preparatory course material in graduate accelerator physics thesis research The text covers historical accelerator development transverse betatron motion synchrotron motion an introduction to linear accelerators and synchrotron radiation phenomena in low emittance electron storage rings introduction to special topics such as the free electron laser and the beam beam interaction Attention is paid to derivation of the action angle variables of the phase space because the transformation is important for understanding advanced topics such as the collective instability and nonlinear beam dynamics Each section is followed by exercises which are designed to reinforce concepts and to solve realistic accelerator design problems Contents Introduction Historical Developments Layout and Components of Accelerators Accelerator Applications Transverse Motion Hamiltonian for Particle Motion in Accelerators Linear Betatron Motion Effect of Linear Magnet Imperfections Off Momentum Orbit Chromatic Aberration Linear Coupling Nonlinear Resonances Collective Instability and Landau Damping Synchro Betatron Hamiltonian Synchrotron Motion Longitudinal Equation of Motion Adiabatic Synchrotron Motion RF Phase and Voltage Modulations Nonadiabatic and Nonlinear Synchrotron Motion Beam Manipulation in Synchrotron Phase Space Fundamentals of RF Systems Longitudinal Collective Instabilities Introduction to Linear Accelerators Physics of Electron Storage Rings Fields of a Moving Charged Particle Radiation Damping and Excitation Emittance in Electron Storage Rings Special Topics in Beam Physics Free Electron Laser FEL Beam Beam Interaction Classical Mechanics and Analysis Hamiltonian Dynamics Stochastic Beam Dynamics Model Independent Analysis Numerical Methods and Physical Constants Fourier Transform Cauchy Theorem and the Dispersion Relation Useful Handy Formulas Maxwell's Equations Physical Properties and Constants Readership Accelerator high energy nuclear plasma and applied physicists

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