

Helmut Wiedemann

# Particle Accelerator Physics II

Nonlinear and Higher-Order  
Beam Dynamics



Springer

# Particle Accelerator Physics Ii Nonlinear And Higherorder Beam Dynamics

**Helmut Wiedemann**



## **Particle Accelerator Physics II Nonlinear And Higherorder Beam Dynamics:**

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 *Particle Accelerator Physics* Helmut Wiedemann,2003 *Particle Accelerator Physics* Helmut Wiedemann,2013-11-27 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,

**Beam Dynamics In High Energy Particle Accelerators (Second Edition)** Andrzej Wolski,2023-05-12 High energy particle accelerators are as diverse as their uses which range from scientific research in fields such as high energy physics materials science and the life sciences to applications in industry and medicine Despite the diversity of accelerators the particle beams that they are designed to produce behave in ways that share many common features Beam Dynamics in High Energy Particle Accelerators aims to provide an introduction to phenomena regularly encountered when working with beams in accelerators from the basic principles of motion of relativistic particles in electromagnetic fields to instabilities that can affect beam quality in machines operating at high current This book assumes no prior experience with accelerator physics and develops the subject in a way that provides a solid foundation for more advanced study of specific topics As well as including numerous revisions and improvements in the text this second edition features substantial new material including sections on fringe fields in multipole magnets Verlet integration for particle tracking and measurement of beam emittances References and discussions of current topics have been updated As with the first edition the aim is to provide practical and powerful tools and techniques for the study of beam dynamics while emphasizing the elegance of the subject and helping the reader develop a deep understanding of the relevant physics *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 straight forward 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      *Accelerator Physics* S Y Lee,2004-12-22 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

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      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      *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      **CERN. ,2009      Saw-tooth Instability Studies at the Stanford Linear Collider Dampening Rings** Boris V. Podobedov, 1999      **Kam Story, The: A Friendly Introduction To**

### **The Content, History, And Significance Of Classical Kolmogorov-arnold-moser Theory** H Scott Dumas,2014-02-28

This is a semi popular mathematics book aimed at a broad readership of mathematically literate scientists especially mathematicians and physicists who are not experts in classical mechanics or KAM theory and scientific minded readers Parts of the book should also appeal to less mathematically trained readers with an interest in the history or philosophy of science The scope of the book is broad it not only describes KAM theory in some detail but also presents its historical context thus showing why it was a breakthrough Also discussed are applications of KAM theory especially to celestial mechanics and statistical mechanics and the parts of mathematics and physics in which KAM theory resides dynamical systems classical mechanics and Hamiltonian perturbation theory Although a number of sources on KAM theory are now available for experts this book attempts to fill a long standing gap at a more descriptive level It stands out very clearly from existing publications on KAM theory because it leads the reader through an accessible account of the theory and places it in its proper context in mathematics physics and the history of science

**Nonlinear Fokker-Planck Equations** T.D. Frank,2005-12-08 Centered around the natural phenomena of relaxations and fluctuations this monograph provides readers with a solid foundation in the linear and nonlinear Fokker Planck equations that describe the evolution of distribution functions It emphasizes principles and notions of the theory e g self organization stochastic feedback free energy and Markov processes while also illustrating the wide applicability e g collective behavior multistability front dynamics and quantum particle distribution The focus is on relaxation processes in homogeneous many body systems describable by nonlinear Fokker Planck equations Also treated are Langevin equations and correlation functions Since these phenomena are exhibited by a diverse spectrum of systems examples and applications span the fields of physics biology and neurophysics mathematics psychology and biomechanics

**Physics of Intensity Dependent Beam Instabilities** King-Yuen Ng,2006 This book provides a comprehensive treatment of intensity dependent particle beam instabilities in accelerating rings Written for researchers the material is also suitable for use as a textbook in an advanced graduate course for students studying accelerator physics The presentation starts with a brief review of the basic concept of wake potentials and coupling impedances in the vacuum chamber followed by a discussion on static and dynamic solutions of their effects on the particle beams Special emphasis is placed separately on proton and electron machines Other special topics of interest covered include Landau damping Balakin Novokhatsky Smirnov damping Sacherer s integral equations Landau cavity saw tooth instability Robinson stability criteria beam loading transition crossing two stream instabilities and collective instability issues of isochronous rings After the formulation of an instability readers are provided a thorough description of one or more experimental observations together with a discussion of the cures for the instability Although the book is theory oriented the use of mathematics has been minimized The presentation is intended to be rigorous and self contained with nearly all the formulas and equations derived

Handbook Of Accelerator Physics And Engineering (Third Edition) Alexander Wu Chao, Maury Tigner, Hans Weise, Frank

Zimmermann, 2023-02-02 Edited by internationally recognized authorities in the field this expanded and updated new edition of the bestselling Handbook containing many new articles is aimed at the design and operation of modern particle accelerators It is intended as a vade mecum for professional engineers and physicists engaged in these subjects With a collection of more than 2000 equations 300 illustrations and 500 graphs and tables here one will find in addition to common formulae of previous compilations hard to find specialized formulae recipes and material data pooled from the lifetime experience of many of the world's most able practitioners of the art and science of accelerators The seven chapters include both theoretical and practical matters as well as an extensive glossary of accelerator types Chapters on beam dynamics and electromagnetic and nuclear interactions deal with linear and nonlinear single particle and collective effects including spin motion beam environment beam beam beam electron beam ion and intrabeam interactions The impedance concept and related calculations are dealt with at length as are the instabilities due to the various interactions mentioned A chapter on operational considerations including discussions on the assessment and correction of orbit and optics errors realtime feedbacks generation of short photon pulses bunch compression phase space exchange tuning of normal and superconducting linacs energy recovery linacs free electron lasers cryogenic vacuum systems steady state microbunching cooling space charge compensation brightness of light sources collider luminosity optimization and collision schemes machine learning multiple frequency rf systems FEL seeding ultrafast electron diffraction and Gamma Factory Chapters on mechanical and electrical considerations present material data and important aspects of component design including heat transfer and refrigeration Hardware systems for particle sources feedback systems confinement including undulators and acceleration both normal and superconducting receive detailed treatment in a sub systems chapter beam measurement and apparatus being treated therein as well A detailed name and subject index is provided together with reliable references to the literature where the most detailed information available on all subjects treated can be found *Nuovo Cimento* ,1997

**Il Nuovo cimento della Società italiana di fisica** ,1997



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