Beam Dynamics In High Energy Particle Accelerators

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Beam Dynamics in High Energy Particle Accelerators Springer
Beam Dynamics in High Energy Particle AcceleratorsWorld Scientific
Beam Dynamics in Heavy Ion Fusion World Scientific
Electron storage rings play a crucial role in many areas of modern scientific research. In light sources, they provide intense beams of x-rays that can be used to understand the structure and behavior of materials at the atomic scale, with applications to medicine, the life sciences, condensed matter physics, engineering, and technology. In particle colliders, electron storage rings allow experiments that probe the laws of nature at the most fundamental level. Understanding and controlling the behavior of the beams of particles in storage rings is essential for the design, construction, and operation of light sources and colliders aimed at reaching increasingly demanding performance specifications. Introduction to Beam Dynamics in High-Energy Electron Storage Rings describes the physics of particle behavior in these machines. Starting with an outline of the history, uses, and structure of electron storage rings, the book develops the foundations of beam dynamics, covering particle motion in the components used to guide and focus the beams, the effects of synchrotron radiation, and the impact of interactions between the particles in the beams. The aim is to emphasize the physics behind key phenomena, keeping mathematical derivations to a minimum: numerous references are provided for those interested in learning more. The text includes discussion of issues relevant to machine design and operation and concludes with a brief discussion of some more advanced topics, relevant in some special situations, and a glimpse of current research aiming to develop the "ultimate" storage rings.
4th Advanced ICFA Beam Dynamics Workshop : Papers and Reports World Scientific
In this paper, we report on progress that has been made in beam dynamics simulation, from light sources to colliders, during the first year of the SciDAC-2 accelerator project 'Community Petascale Project for Accelerator Science and Simulation (ComPASS).' Several parallel computational tools for beam dynamics simulation are described. Also presented are number of applications in current and future accelerator facilities (e.g., LCLS, RHIC, Tevatron, LHC, and ELIC). Particle accelerators are some of most important tools of scientific discovery. They are widely used in high-energy physics, nuclear physics, and other basic and applied sciences to study the interaction of elementary particles, to probe the internal structure of matter, and to generate high-brightness radiation for research in materials science, chemistry, biology, and other fields. Modern accelerators are complex and expensive devices that may be several kilometers long and may consist of thousands of beamline elements. An accelerator may transport trillions of charged particles that interact electromagnetically among themselves, that interact with fields produced by the accelerator components, and that interact with beam-induced fields. Large-scale beam dynamics simulations on massively parallel computers can help provide understanding of these complex physical phenomena, help minimize design cost, and help optimize machine operation. In this paper, we report on beam dynamics simulations in a variety of accelerators ranging from next generation light sources to high-energy ring colliders that have been studied during the first year of the SciDAC-2 accelerator project.
Nonlinear Dynamics And Collective Effects In Particle Beam Physics - Proceedings Of The International Committee On Future Accelerators Arcidosso Italy 2017 Springer Science & Business Media
In this volume, the author lays down the foundations of a theory of rings based on finite maps. The purpose and goals of the ring are discussed entirely in terms of the global properties of the one-turn map. Since 1987, the author and his associates have been proposing a theory of rings based on such maps. This work, the first introduction to this theoretical method, offers a modern and unique perspective on storage ring theory, which should be of interest to engineers and graduate and research level physicists in the international accelerator physics community, as well as to applied mathematicians. Interactive exercises for use with this book are available via the World Wide Web.
Quantum Aspects of Beam Physics Beam Dynamics in High Energy Particle Accelerators
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 wel comes 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. Parti cle 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 World Scientific
An electron lens is planned for the Fermilab Integrable Optics Test Accelerator as a nonlinear element for integrable dynamics, as an electron cooler, and as an electron trap to study space-charge compensation in rings. We present the main design principles and constraints for nonlinear integrable optics. A magnetic configuration of the solenoids and of the toroidal section is laid out. Singleparticle tracking is used to optimize the electron path. Electron beam dynamics at high intensity is calculated with a particle-in-cell code to estimate current limits, profile distortions, and the effects on the circulating beam. In the conclusions, we summarize the main findings and list directions for further work.
The Joint 28th ICFA Advanced Beam Dynamics and Advanced & Novel Accelerators Workshop, Hiroshima, Japan, 7-11 January 2003 Springer Science & Business Media
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
An Introduction Springer
The Advent of laser-ion-guiding in the Advanced test Accelerator along with the development of accelerator cavities optimized with respect to beam breakup coupling impedence now make it possible to consider a new class of high current, high emergy linear induction accelerators. The control of the beam breakup and other instabilities by laser guiding and by various magnetic focusing schemes will be discussed along with the scaling laws for the design of such machines to minimize the growth of the beam breakup instability. Many linacs, particularly induction linacs are limited in performance by the beam breakup (BBU) instability. The instability is found in two forms. In the first form the accelerating cavities communicate with one another through interaction with the beam and through propagation of cavity fields through the accelerator structure. In the second form which is the more virulent of the two, the cavities couple to each other only through their interactions with the beam. It is this second form of PPU that will be discussed in this paper.
Introduction to Beam Dynamics in High-Energy Electron Storage Rings Morgan & Claypool Publishers
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/ionsources,(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 DevelopmentsLayout and Components of AcceleratorsAccelerator ApplicationsTransverse Motion:Hamiltonian for Particle Motion in AcceleratorsLinear Betatron MotionEffect of Linear Magnet ImperfectionsOff-Momentum OrbitChromatic AberrationLinear CouplingNonlinear ResonancesCollective Instability and Landau DampingSynchro-Betatron HamiltonianSynchrotron Motion:Longitudinal Equation of MotionAdiabatic Synchrotron MotionRF Phase and Voltage ModulationsNonadiabatic and Nonlinear Synchrotron MotionBeam Manipulation in Synchrotron Phase SpaceFundamentals of RF SystemsLongitudinal Collective InstabilitiesIntroduction to Linear AcceleratorsPhysics of Electron Storage Rings:Fields of a Moving Charged ParticleRadiation Damping and ExcitationEmittance in Electron Storage RingsSpecial Topics in Beam Physics:Free Electron Laser (FEL)Beam-Beam InteractionClassical Mechanics and Analysis:Hamiltonian DynamicsStochastic Beam DynamicsModel Independent AnalysisNumerical Methods and Physical Constants:Fourier TransformCauchy Theorem and the Dispersion RelationUseful Handy FormulasMaxwell's EquationsPhysical Properties and Constants Readership: Accelerator, high-energy, nuclear, plasma and applied physicists.
From Light Sources to Colliders CRC Press
We had carried out a design of an ultimate storage ring with beam emittance less than 10 picometer for the feasibility of coherent light source at X-ray wavelength. The accelerator has an inherent small dynamic aperture. We study method to improve the dynamic aperture and collective instability for an ultimate storage ring. Beam measurement and accelerator modeling are an integral part of accelerator physics. We develop the independent component analysis (ICA) and the orbit response matrix method for improving accelerator reliability and performance. In collaboration with scientists in National Laboratories, we also carry out experimental and theoretical studies on beam dynamics. Our proposed research topics are relevant to nuclear and particle physics using high brightness particle and photon beams.
Future Perspectives In High Energy Physics - Proceedings Of The 1990 Icfa Seminars World Scientific
Electron storage rings play a crucial role in many areas of modern scientific research. Introduction to Beam Dynamics in High-Energy Electron Storage Rings describes the physics of particle behaviour in these machines. Starting with an outline of the history, uses and structure of electron storage rings, the book develops the foundations of beam dynamics, covering particle motion in the components used to guide and focus the beams, the effects of

synchrotron radiation, and the impact of interactions between the particles in the beams.

Quantum Aspects Of Beam Physics - Advanced Icfa Beam Dynamics Workshop World Scientific Publishing Company

A standard design for heavy ion fusion drivers under study in the US is an induction linac with electrostatic focusing at low energy and magnetic focusing at higher energy. The need to focus the intense beam to a few-millimeter size spot at the deuterium-tritium target establishes the emittance budget for the accelerator. Economic and technological considerations favor a larger number of beams in the low-energy, electrostatic-focusing section than in the high-energy, magnetic-focusing section. Combining four beams into a single focusing channel is a viable option, depending on the growth in emittance due to the combining process. Several significant beam dynamics issues that are, or have been, under active study are discussed: large space charge and image forces, beam wall clearances, halos, alignment, longitudinal instability, and bunch length control.

Investigation and Optimization of Transverse Non-linear Beam Dynamics in the High-energy Storage Ring HESR World Scientific

Superconducting linacs are capable of producing intense, ultra-stable, high-quality electron beams that have widespread applications in Science and Industry. Many project are based on the 1.3-GHz TESLA-type superconducting cavity. In this paper we provide an update on a recent experiment aimed at measuring the transfer matrix of a TESLA cavity at the Fermilab Accelerator Science and Technology (FAST) facility. The results are discussed and compared with analytical and numerical simulations.

Particle Accelerator Physics: Nonlinear and higher-order beam dynamics World Scientific

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.

Longitudinal Beam Dynamics and LLRF Requirements for Project X Pulsed Linac World Scientific

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.

Morgan & Claypool Publishers

This proceedings volume of the 3rd International Workshop on Quantum Aspects of Beam Physics, presents the latest advances in beam dynamics. The frontiers of beam research point to increasingly high energy, greater brightness and lower emittance beams with ever-increasing particle species. These demands have triggered a rapidly growing number of beam phenomena that involve quantum effects. In addition to the more established topics, this volume covers topics on high energy-density particle and photon beams for laboratory astrophysics investigations, as well as the application of beam physics expertise to astrophysics studies. Other exciting new topics are the physics of ultra-cold or condensed beams, such as the ''''crystalline beams'''' and the BoseOCoEinstein condensate ''''atom lasers''''. This book will be a valuable source of reference to readers interested in the interdisciplinary frontiers of ''''quantum beam physics'''' that involve beam physics, particle physics, laser science, astrophysics, condensed matter physics, nuclear and atomic physics. The proceedings have been selected for coverage in: . OCo Index to Scientific & Technical Proceedings- (ISTP- / ISI Proceedings). OCo Index to Scientific & Technical Proceedings (ISTP CDROM version / ISI Proceedings). OCo CC Proceedings OCo Engineering & Physical Sciences."

Beam Manipulation Techniques, Nonlinear Beam Dynamics, and Space Charge Effect in High Energy High Power Accelerators Springer Science & Business Media

The application horizon of particle accelerators has been widening significantly in recent decades. Where large accelerators have traditionally been the tools of the trade for high-energy nuclear and particle physics, applications in the last decade have grown to include large-scale accelerators like synchrotron light sources and spallation neutron sources. Applications like generation of rare isotopes, transmutation of nuclear reactor waste, sub-critical nuclear power, generation of neutrino beams etc. are next area of investigation for accelerator scientific community all over the world. Such applications require high beam power in the range of few mega-watts (MW). One such high intensity proton beam facility is proposed at Fermilab, Batavia, US, named as Project-X. Project-X facility is based on H- linear accelerator (linac), which will operate in continuous wave (CW) mode and accelerate H- ion beam with average current of 1 mA from kinetic energy of 2.5 MeV to 3 GeV to deliver 3MW beam power. One of the most challenging tasks of the Project-X facility is to have a robust design of the CW linac which can provide high quality beam to several experiments simultaneously. Hence a careful design of linac is important to achieve this objective.

Proceedings of the 39th ICFA Advanced Beam Dynamics Woorkshop High Intensity, High Brightness Hadron Beams Tsukuba, Japan, May 29-June 2, 2006 Morgan & Claypool

This book examines the acceleration and storage of polarized proton beams in cyclic accelerators. Basic equations of spin motion are reviewed, the invariant spin field is introduced, and an adiabatic invariant of spin motion is derived. The text presents numerical methods for computing the invariant spin field, and displays the results in numerous illustrations. This book offers a more lucid view of spin dynamics at high energy than has hitherto been available.

Accelerator Physics

This book contains the proceedings of the 1999 ICFA workshop on the physics of high brightness beams. The workshop took a snapshot in time of a fast moving, interdisciplinary field driven by advanced applications such as high gradient, high energy physics linear colliders, high gain free electron lasers, heavy ion fusion, and transmutation of nuclear materials. While the field of high brightness beam physics has traditionally been divided into disparate electron and heavy ion communities, the workshop brought the two types of researchers together, so that a sharing of insights and methods could be achieved. Thus, this book represents a unifying step in the development of the diverse fascinating discipline of high brightness beam physics, with its challenges rooted in collective, nonlinear particle motion and ultra-high electromagnetic energy density. Contents:Application of High-Brightness Electron Beams (M J van der Wiel)Beam Halo Formation in High Intensity Proton Beams (T P Wangler)Matching of High-Brightness Electron and Ion Beams in Variably Focusing Channels (R Pakter & C Chen)A Particle-Core Model for Transverse Dynamics of Beam Halo in Periodic Focusing Channels (T F Wang)Formation of Patterns in Intense Hadron Beams. The Amplitude Equation Approach (S I Tzenov)Progress on the Study of CSR Effects (R Li)Optimization of Smith-Purcell Radiation from a Perfectly Conducting Strip Grating (S R Trotz)Single Crystal Copper Photo and Cathode in the BNL/SLAC/UCLA 1.6 Cell RF Gun (D T Palmer et al.)Recent Developments of the MIT 17 GHz RF Gun Experiment (W J Brown et al.)HOMDYN Study for the LCLS RF Photo-Injector (M Ferrario et al.)Compact, Integrated Photoelectron Linacs (D Yu)and other papers Readership: Researchers in accelerator physics. Keywords:Beam;Transmutation;Particle;Accelerator

High Energy Polarized Proton Beams

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.