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Magnetohydrodynamic Equilibrium and Stability of Stellarators



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In this book we describe in detail a numerical method to study the equilibrium and stability of a plasma confined by a strong magnetic field in toroidal geometry without two dimensional symmetry The principal application is to stellarators which are currently of interest in thermonuclear fusion research Our mathematical model is based on the partial differential equations of ideal magnetohydrodynamics The main contribution is a computer code named BETA that is listed in the final chapter This work is the natural continuation of an investigation that was presented in an early volume of the Springer Series in Computational Physics of 3 It has been supported over a period of years by the U S Department of Energy under Contract DE AC02 76ER03077 with New York University We would like to express our gratitude to Dr Franz Herrnegger for the assistance he has given us with the preparation of the manuscript We are especially indebted to Connie Engle for the high quality of the final typescript New York F BAUER October 1983 O BETANCOURT P GARABEDIAN Contents 1 Introduction 1 2 Synopsis of the Method 3 1 Variational principle 3 2 Coordinate system 6 3 Finite Difference Scheme 8 1 Difference equations 8 2 Island structure 10 3 Accelerated iteration procedure 12 Nonlinear Stability 15 4 1 Second minimization 15 2 Test functions and convergence studies 17 3 Comparison with exact solutions 19 5 The Mercier Criterion 22 1 Local mode analysis 22 2 Computational method 23

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Fusion Energy Update, 1986 Stellarator and Heliotron Devices Masahiro Wakatani, 1998 This monograph describes plasma physics for magnetic confinement of high temperature plasmas in nonaxisymmetric toroidal magnetic fields or stellarators The techniques are aimed at controlling nuclear fusion for continuous energy production While the focus is on the nonaxisymmetric toroidal field or heliotron developed at Kyoto University the physics applies equally to other stellarators and axisymmetric tokamaks The author covers all aspects of magnetic confinement formation of magnetic surfaces magnetohydrodynamic equilibrium and stability single charged particle confinement neoclassical transport and plasma heating He also reviews recent experiments and the prospects for the next generation of devices

An Introduction to Stellarators Lise-Marie Imbert-Gérard, Elizabeth J. Paul, Adelle M. Wright, 2024-12-10 This self contained book is the first to provide readers with an introduction to the mathematical foundations of stellarator design and modeling It covers the fundamental theoretical building blocks of modeling magnetic fields some of the associated challenges and the main concepts behind optimization for the design of stellarators The book is divided into two parts with Part I providing a general introduction to the stellarator concept and Part II describing mathematical models and numerical methods commonly used in stellarator design The authors derive present and discuss relevant models using equations and figures to demonstrate the main ideas They carefully select language that is close to the plasma physics literature while providing enough details to be accessible to a reader without previous background in this field An Introduction to Stellarators From Magnetic Fields to Symmetries and Optimization is intended for mathematicians physicists and engineers interested in learning about stellarators Readers are expected to have a basic knowledge of classical physics partial differential equations and variational calculus but prior knowledge of plasma physics is not required

Extension of

Stellarator Approximation in Magnetohydrodynamic Equilibrium and Stability of Toroidal Helical Systems Jiro Todoroki, Nagoya Daigaku. Purazuma Kenkyūjo, 1989 Ideal MHD Jeffrey P. Freidberg, 2014-06-26 Comprehensive self contained and clearly written this successor to Ideal Magnetohydrodynamics 1987 describes the macroscopic equilibrium and stability of high temperature plasmas the basic fuel for the development of fusion power Now fully updated this book discusses the underlying physical assumptions for three basic MHD models ideal kinetic and double adiabatic MHD Included are detailed analyses of MHD equilibrium and stability with a particular focus on three key configurations at the cutting edge of fusion research the tokamak stellarator and reversed field pinch Other new topics include continuum damping MHD stability comparison theorems neoclassical transport in stellarators and how quasi omnigenity quasi symmetry and quasi isodynamic constraints impact the design of optimized stellarators Including full derivations of almost every important result in depth physical explanations throughout and a large number of problem sets to help master the material this is an exceptional resource for graduate students and researchers in plasma and fusion physics **Computational Techniques And Applications: Ctac 95 - Proceedings Of The Seventh Biennial Conference** Robert L May, Alan K Easton, 1996-08-30 This proceedings contains seven invited papers and 100 contributed papers The topics covered range from studies of theoretical aspects of computational methods through to simulations of large scale industrial processes with an emphasis on the efficient use of computers to solve practical problems Developers and users of computational techniques who wish to keep up with recent developments in the application of modern computational technology to problems in science and engineering will find much of interest in this volume **Fundamentals of Plasma Physics and Controlled Fusion** Arjun Goswami, 2025-02-20 Fundamentals of Plasma Physics and Controlled Fusion is a comprehensive guide to plasma physics and the quest for controlled fusion energy We explore the study of plasmas the fourth state of matter made up of charged particles and delve into the potential of controlled fusion to create clean energy by fusing atomic nuclei We cover the basics of plasma physics including plasma behavior and creation and dive deep into controlled fusion explaining its science and the challenges of building a practical fusion reactor The book is written clearly and accessibly making it valuable for both students and researchers It also discusses fusion energy s potential to address global energy problems Fundamentals of Plasma Physics and Controlled Fusion is an essential resource for anyone interested in this exciting field of research Scientific and Technical Aerospace Reports , 1995 Fusion Part B Edward Teller, 2012-12-02 Fusion Volume I Magnetic Confinement Part B is the second of the two part volume that covers the complexity and application of controlled magnetic fusion This part is composed of nine chapters and begins with a description of the heating methods equilibrium and stability of linear magnetic fusion systems The next chapters deal with the principles configuration and application of high beta stellarator fast linear compression fusion systems and ELMO Bumpy torus as well as the magnetic confinement of high temperature plasmas These topics are followed by discussions of the neutral beam injection the regimes of radio frequency

heating of magnetically confined plasma and the performance requirements of magnetic fusion reactors The final chapters describe the basic processes in the fusion fission fuel factory and some basic considerations for advanced fuel reactors This book will be of great value to physicists physics students and researchers

Systems Approaches to Nuclear Fusion Reactors Frederick B. Marcus, 2023-01-01 This book offers an overall review applying systems engineering and architecture approaches of the design optimization operation and results of leading fusion experiments These approaches provide a unified means of evaluating reactor design Methodologies are developed for more coherent construction or evaluation of fusion devices associated experiments and operating procedures The main focus is on tokamaks with almost all machines and their important results being integrated into a systems design space Case studies focus on DIII D TCV JET WEST the fusion reactor prototype ITER and the EU DEMO concept Stellarator Mirror and Laser inertial confinement experiments are similarly analysed including reactor implications of breakeven at NIF The book examines the engineering and physics design and optimization process for each machine analysing their performance and major results achieved thus establishing a basis for the improvement of future machines The reader will gain a broad historical and up to date perspective of the status of nuclear fusion research from both an engineering and physics point of view Explanations are given of the computational tools needed to design and operate successful experiments and reactor relevant machines This book is aimed at both graduate students and practitioners of nuclear fusion science and engineering as well as those specializing in other fields demanding large and integrated experimental equipment Systems engineers will obtain valuable insights into fusion applications References are given to associated complex mathematical derivations which are beyond the scope of this book The general reader interested in nuclear fusion will find here an accessible summary of the current state of nuclear fusion

Computational Methods in Optimal Control William H. Hager, 2025-02-13 Using material from many different sources in a systematic and unified way this self contained book provides both rigorous mathematical theory and practical numerical insights while developing a framework for determining the convergence rate of discrete approximations to optimal control problems Elements of the framework include the reference point the truncation error and a stability theory for the linearized first order optimality conditions Within this framework the discretized control problem has a stationary point whose distance to the reference point is bounded in terms of the truncation error The theory applies to a broad range of discretizations and provides completely new insights into the convergence theory for discrete approximations in optimal control including the relationship between orthogonal collocation and Runge Kutta methods Throughout the book derivatives associated with the discretized control problem are expressed in terms of a back propagated costate In particular the objective derivative of a bang bang or singular control problem with respect to a switch point of the control are obtained which leads to the efficient solution of a class of nonsmooth control problems using a gradient based optimizer Computational Methods in Optimal Control Theory and Practice is intended for numerical analysts and computational scientists Users of the software package

GPOPS may find the book useful since the theoretical basis for the GPOPS algorithm is developed within the book It is appropriate for courses in variational analysis numerical optimization and the calculus of variations

Energy Research Abstracts ,1995 [Advanced Fusion Concepts Project Summaries](#) ,1983-06 *Fusion Part A* Edward Teller,2012-12-02

Fusion Volume I Magnetic Confinement Part A is the first of the two part volume that covers the complexity and application of controlled magnetic fusion This book is divided into seven chapters and starts with a brief historical overview and some properties of controlled fusion The subsequent chapters deal with the principles thermodynamic stability and configuration of Tokamak plasma These topics are followed by discussions of the variations and application of stellarators the concepts of mirror theory and the establishment of the experimental basis of the mirror confinement physics The last chapter focuses on the principles configuration and application of the reversed field pinch This book will prove useful to physicists physics students and researchers

Theory of Fusion Plasmas Elio Sindoni,Francis Troyon,J. Vaclavik,1990 **Computational Physics: Proceedings Of The Cp90 International Conference** Armin G Tenner,1991-04-30 The invited talks include applications from the fields of solid state physics plasma physics hydrodynamics high energy physics thermodynamics atomic and molecular physics chemistry statistical physics earth sciences neural networks meteorology astrophysics and presentations on cellular automata and quantum Monte Carlo methods The emphasis is on methods of software development and engineering graphic tools and storage of physical data

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