Lattice Boltzmann Method Theory And Application Simulation Of The Crud Formation Process Using The Lattice Boltzmann Method

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The Lattice Boltzmann Equation

This unique professional volume is about the recent advances in the lattice Boltzmann method (LBM). It introduces a new methodology, namely the simplified and highly stable lattice Boltzmann method (SHSLBM), for constructing numerical schemes within the lattice Boltzmann framework. Through rigorous mathematical derivations and abundant numerical validations, the SHSLBM is found to outperform the conventional LBM in terms of memory cost, boundary treatment and numerical stability.This must-have title provides every necessary detail of the SHSLBM and sample codes for implementation. It is a useful handbook for scholars, researchers, professionals and students who are keen to learn, employ and further develop this novel numerical method.

Fractals in Rock Mechanics

This new edition incorporates corrections of all known typographical errors in the first edition, as well as some more substantive changes. Chief among the latter is the addition of Chap. 17, on methods of estimation. As with the rest of the text, most applications and examples cited in the new chapter are from the optical perspective. The intention behind this new chapter is to empower the optical researcher with a yet broader range of research tools. Certainly a basic knowledge of estimation methods should be among these. In particular, the sections on likelihood theory and Fisher information prepare readers for the problems of optical parameter estimation and probability law estimation. Physicists and optical scientists might find this material particularly useful, since the subject of Fisher information is generally not covered in standard physical science curricula. Since the words "statistical optics" are prominent in the title of this book, their meaning needs to be clarified. There is a general tendency to overly emphasize the statistics of photons as the sine qua non of statistical optics. In view is taken, which equally emphasizes the random medium this text a wider that surrounds the photon, be it a photographic emulsion, the turbulent atmo sphere, a vibrating lens holder, etc. Also included are random interpretations of ostensibly deterministic phenomena, such as the Hurter-Driffield (H and D) curve of photography. Such a "random interpretation" sometimes breaks new ground, as in Chap.

Lattice Boltzmann Method, Theory and Application

Theory and Application of Multiphase Lattice Boltzmann Methods presents a comprehensive review of all popular multiphase Lattice Boltzmann Methods developed thus far and is aimed at researchers and practitioners within relevant Earth Science disciplines as well as Petroleum, Chemical, Mechanical and Geological Engineering. Clearly structured throughout, this book will be an invaluable reference on the current state of all popular multiphase Lattice Boltzmann Methods (LBMs). The advantages and disadvantages of each model are presented in an accessible manner to enable the reader to choose the model most suitable for the problems they are interested in. The book is targeted at graduate students and researchers who plan to investigate multiphase flows using LBMs. Throughout the text most of the popular multiphase LBMs are analyzed both theoretically and through numerical simulation. The authors present many of the mathematical derivations of the models in greater detail than is currently found in the existing literature. The approach to understanding and classifying the various models is principally based on simulation compared against analytical and observational results and discovery of undesirable terms in the derived macroscopic equations and sometimes their correction. A repository of FORTRAN codes for multiphase LBM models is also provided.

High Performance Computing and Applications

Turbulent combustion sits at the interface of two important nonlinear, multiscale phenomena: chemistry and turbulence. Its study is extremely timely in view of the need to develop new combustion technologies in order to address challenges associated with climate change, energy source uncertainty, and air pollution. Despite the fact that modeling of turbulent combustion is a subject that has been researched for a number of years, its complexity implies that key issues are still eluding, and a theoretical description that is accurate enough to make turbulent combustion models rigorous and quantitative for industrial use is still lacking. In this book, prominent experts review most of the available approaches in modeling turbulent combustion, with particular focus on the exploding increase in computational resources that has allowed the simulation of increasingly detailed phenomena. The relevant algorithms are presented, the theoretical methods are explained, and various application examples are given. The book is intended for a relatively broad audience, including seasoned researchers and graduate students in engineering, applied mathematics and computational science, engine designers and computational fluid dynamics (CFD) practitioners, scientists at funding agencies, and anyone wishing to understand the state-of-the-art and the future directions of this scientifically challenging and practically important field.

Lattice-Gas Cellular Automata

Doctoral Thesis / Dissertation from the year 2007 in the subject Mathematics - Analysis, University of Constance (Fachbereich Mathematik & Statistik), 69 entries in the bibliography, language: English, comment: Die Arbeit wurde mit 1 (magna cum laude bewertet) und enthalt farbige Abbildungen., abstract: Lattice-Boltzmann algorithms represent a quite novel class of numerical schemes, which are used to solve evolutionary partial differential equations (PDEs). In contrast to other methods (FEM, FVM), lattice-Boltzmann methods rely on a mesoscopic approach. The idea consists in setting up an artificial, grid-based particle dynamics, which is chosen such that appropriate averages provide approximate solutions of a certain PDE, typically in the area of fluid dynamics. As lattice-Boltzmann schemes are closely related to finite velocity Boltzmann equations being singularly perturbed by special scalings, their consistency is not obvious. This work is concerned with the analysis of lattice-Boltzmann methods also focusing certain numeric phenomena like initial layers, multiple time scales and boundary layers. As major analytic tool, regular (Hilbert) expansions are employed to establish consistency. Exemplarily, two and three population algorithms are studied in one space dimension, mostly discretizing the advection-diffusion equation. It is shown how these model schemes can be derived from two-dimensional schemes in the case of special symmetries. The analysis of the schemes is preceded by an examination of the singular limit being characteristic of the corresponding scaled finite velocity Boltzmann equations. Convergence proofs are obtained using a Fourier series approach and alternatively a general regular expansion combined with an energy estimate. The appearance of initial layers is investigated by multiscale and irregular expansions. Among others, a hierarchy of equations is found which gives insight into the internal coupling of the initial layer and the regular par

The Lattice Boltzmann Equation

Simplified And Highly Stable Lattice Boltzmann Method: Theory And Applications

Programming has become a significant part of connecting theoretical development and scientific application computation. Fluid dynamics provide an important asset in experimentation and theoretical analysis. Analysis and Applications of Lattice Boltzmann Simulations provides emerging research on the efficient and standard implementations of simulation methods on current and upcoming parallel architectures. While highlighting topics such as hardware accelerators, numerical analysis, and sparse geometries, this publication explores the techniques of specific simulators as well as the multiple extensions and various uses. This book is a vital resource for engineers, professionals, researchers, academics, and students seeking current research on computational fluid dynamics, high-performance computing, and numerical and flow simulations.

Lattice Gas Methods

Nature continuously presents a huge number of complex and multi-scale phenomena, which in many cases, involve the presence of one or more fluids flowing, merging and evolving around us. Since its appearance on the surface of Earth, Mankind has tried to exploit and tame fluids for their purposes, probably starting with Hero's machinery to open the doors of the Temple of Serapis in Alexandria to arrive to modern propulsion systems and actuators. Today we know that fluid mechanics lies at the basis of countless scientific and technical applications from the smallest physical scales (nanofluidics, bacterial motility, and diffusive flows in porous media), to the largest (from energy production in power plants to oceanography and meteorology). It is essential to deepen the understanding of fluid behaviour across scales for the progress of Mankind and for a more sustainable and efficient future. Since the very first years of the Third Millennium, the Lattice Boltzmann Method (LBM) has seen an exponential growth of applications, especially in the fields connected with the simulation of complex and soft matter flows. LBM, in fact, has shown a remarkable versatility in different fields of applications from nanoactive materials, free surface flows, and multiphase and reactive flows to the simulation of the processes inside engines and fluid machinery. LBM is based on an optimized formulation of Boltzmann's Kinetic Equation, which allows for the simulation of fluid particles, or rather quasi-particles, from a mesoscopic point of view thus allowing the inclusion of more fundamental physical interactions in respect to the standard schemes adopted with Navier-Stokes solvers, based on the continuum assumption. In this book, the authors present the most recent advances of the application of the LBM to complex flow phenomena of scientific and technical interest with particular focus on the multi-scale modeling of heterogeneous catalysis within nano-porous media and multiphase, multicomponent flows.

Probability, Statistical Optics, and Data Testing

This book covers the fundamental and practical application of the Lattice Boltzmann method (LBM). This method is a relatively new simulation technique for the modeling of complex fluid systems and has attracted interest from researchers in computational physics.

The Lattice Boltzmann Method

Certain forms of the Boltzmann equation, have emerged, which relinquish most mathematical complexities of the true Boltzmann equation. This text provides a detailed survey of Lattice Boltzmann equation theory and its major applications.

Analysis of Lattice-Boltzmann Methods

This book introduces readers to the lattice Boltzmann method (LBM) for solving transport phenomena – flow, heat and mass transfer – in a systematic way. Providing explanatory computer codes throughout the book, the author guides readers through many practical examples, such as: • flow in isothermal and non-isothermal lid-driven cavities; • flow over obstacles; • forced flow through a heated channel; • conjugate forced convection; and • natural convection. Diffusion and advection–diffusion equations are discussed, together with applications and examples, and complete computer codes accompany the sections on single and multi-relaxation-time methods. The codes are written in MatLab. However, the codes are written in a way that can be easily converted to other languages, such as FORTRANm Python, Julia, etc. The codes can also be extended with little effort to multi-phase and multi-physics, provided the physics of the respective problem are known. The second edition of this book adds new chapters, and includes new theory and applications. It discusses a wealth of practical examples, and explains LBM in connection with various engineering topics, especially the transport of mass, momentum, energy and molecular species. This book offers a useful and easy-to-follow guide for readers with some prior experience with advanced mathematics and physics, and will be of interest to all researchers and other readers who wish to learn how to apply LBM to engineering and industrial problems. It can also be used as a textbook for advanced undergraduate or graduate courses on computational transport phenomena

Rarefied Gas Dynamics

Lattice Boltzmann Method introduces the lattice Boltzmann method (LBM) for solving transport phenomena – flow, heat and mass transfer – in a systematic way. Providing explanatory computer codes throughout the book, the author guides readers through many practical examples, such as: flow in isothermal and non-isothermal lid driven cavities; flow over obstacles; forced flow through a heated channel; conjugate forced convection; and natural convection. Diffusion and advection-diffusion equations are discussed with applications and examples, and complete computer codes accompany the coverage of single and multi-relaxation-time methods. Although the codes are written in FORTRAN, they can be easily translated to other languages, such as C++. The codes can also be extended with little effort to multi-phase and multi-physics, if the reader knows the physics of the problem. Readers with some experience of advanced mathematics and physics will find Lattice Boltzmann Method a useful and easy-to-follow text. It has been written for those who are interested in learning and applying the LBM to engineering and industrial problems and it can also serve as a textbook for advanced undergraduate or graduate students who are studying computational transport phenomena.

Fluid-structure Interaction Using Lattice Boltzmann Method: Moving Boundary Treatment and Discussion of Compressible Effect

In this paper a procedure for systematic a priori derivation of the lattice Boltzmann models for non-ideal gases from the Enskog equation (the modified Boltzmann equation for dense gases) is presented. This treatment provides a unified theory of lattice Boltzmann models for non-ideal gases. The lattice Boltzmann equation is systematically obtained by discretizing the Enskog equation in phase space and time. The lattice Boltzmann model derived in this paper is thermodynamically consistent up to the order of discretization error. Existing lattice Boltzmann models for non-ideal gases are analyzed and compared in detail. Evaluation of these models are made in light of the general procedure to construct the lattice Boltzmann model for non-ideal gases presented in this work.

Lattice Gas Hydrodynamics

Highlights: A new moving boundary treatment based on BB method is proposed. FG method shows high reliability and stability in simulation. Vibration of cylinder in fluid is investigated using LBM. Compressible effect of LBM is investigated. Abstract: We investigate fluid-structure interaction using lattice Boltzmann method (LBM), where we introduce a new simple treatment for moving boundary. Sub-grids are defined to separate structures from main-grid, thus structures can be created and calculated independently. Mapping and interpolation are used to connect main-grid and sub-grids. Our proposed simulation approach demonstrates high reliability and stability when compared to the direct bounce back method available in the literature. We validate the proposed approach by simulations of a single vibration cylinder in still water and in flowing water. The results show good agreement with theory and reference experiments. We find a delay of fluid force in the simulation of compact cylinder array, and conclude that Mach number (Ma) and boundary force term have a great influence on the accuracy of calculation results. Ma should be carefully chosen for a reliable result. Compressible effect in LBM and its influence on calculation of fluid-structure interaction, which has not been studied in detail, are also discussed in this paper. It is hard to avoid time delay effect under the framework of LBM according to the analysis, and this may lead to inaccurate results in fluid-structure interaction calculation using LBM under certain conditions, which deserve more attention. This paper investigates the vibration of structure in fluid using LBM, which will support the research for fluid induced vibration.

Turbulent Combustion Modeling

Looking for the real state of play in computational many-particle physics? Look no further. This book presents an overview of state-of-the-art numerical methods for studying interacting classical and quantum many-particle systems. A broad range of techniques and algorithms are covered, and emphasis is placed on their implementation on modern high-performance computers. This excellent book comes complete with online files and updates allowing readers to stay right up to date.

Theory of the Lattice Boltzmann Method: Lattice Boltzmann Models for Non-ideal Gases

This book uses the Lagrangian approach, especially useful and convenient for studying large-scale transport and mixing in the ocean, to present a detailed view of ocean circulation. This approach focuses on simulations and on monitoring the trajectories of fluid particles, which are governed by advection equations. The first chapter of the book is devoted to dynamical systems theory methods, which provide the framework, methodology and key concepts for the Lagrangian approach. The book then moves on to an analysis of chaotic mixing and cross-stream transport in idealized models of oceanic meandering currents like the Gulfstream in the Atlantic, the Kuroshio in the Pacific, and Antarctic Circumpolar Current, after which the current state of physical oceanography is reviewed. The latter half of the book applies the techniques and methods already described in order to study eddies, currents, fronts and large-scale mixing and transport in the Far-Eastern seas and the north-western part of the Pacific Ocean. Finally, the book concludes with a discussion of Lagrangian simulation and monitoring of water contamination after the Fukushima disaster of 2011. The propagation of Fukushima-derived radionuclides, surface transport across the Kuroshio Extension current, and the role of mesoscale eddies in the transport of Fukushima-derived cesium isotopes in the ocean are examined, and a comparison of simulation results with actual measurements are presented.Written by some of the world leaders in the application of Lagrangian methods in oceanography, this title will be of benefit to the oceanographic community by presenting the necessary background of the Lagrangian approach in an accessible manner.

Lattice Boltzmann Method and Its Applications in Engineering

Computational fluid dynamics (CFD) has been widely applied in a wide variety of industrial applications, including aeronautics, astronautics, energy, chemical, pharmaceuticals, power and petroleum.This unique compendium documents the recent developments in CFD based on kinetic theories, introducing flux reconstruction strategies of kinetic methods for the simulation of complex incompressible and compressible flows, namely the lattice Boltzmann and the gas kinetic flux solvers (LBFS or GKFS). LBFS and GKFS combine advantages of both Navier-Stokes (N-S) solvers and kinetic solvers.Detailed derivations, evaluations and applications of LBFS and GKFS, and their advantages over conventional flux reconstruction strategies are analyzed and discussed in the volume.The must-have reference text is useful for scholars, researchers, professionals and students who are keen in CFD methods and numerical simulations.

Analysis and Applications of Lattice Boltzmann Simulations

The present book contains contributions presented at the Fourth Symposium on Hybrid RANS-LES Methods, held in Beijing, China, 28-30 September 2011, being a continuation of symposia taking place in Stockholm (Sweden, 2005), in Corfu (Greece, 2007), and Gdansk (Poland, 2009). The contributions to the last two symposia were published as NNFM, Vol. 97 and Vol. 111. At the Beijing symposium, along with seven invited keynotes, another 46 papers (plus 5 posters) were presented addressing topics on Novel turbulence-resolving simulation and modelling, Improved hybrid RANS-LES methods, Comparative studies of difference modelling methods, Modelling-related numerical issues and Industrial applications.. The present book reflects recent activities and new progress made in the development and applications of hybrid RANS-LES methods in general.

Engineering Applications of Computational Fluid Dynamics

Molecular Gas Dynamics

Certain forms of the Boltzmann equation, have emerged, which relinquish most mathematical complexities of the true Boltzmann equation. This text provides a detailed survey of Lattice Boltzmann equation theory and its major applications.

Lattice Boltzmann Methods for Shallow Water Flows

Computational Hydrodynamics of Capsules and Biological Cells

This book constitutes the thoroughly refereed post-conference proceedings of the Second International Conference on High Performance Computing and Applications, HPCA 2009, held in Shangahi, China, in August 2009. The 71 revised papers presented together with 10 invited presentations were carefully selected from 324 submissions. The papers cover topics such as numerical algorithms and solutions; high performance and grid computing; novel approaches to high performance computing; massive data storage and processsing; and hardware acceleration.

Lattice-Gas Cellular Automata and Lattice Boltzmann Models

This book is an introduction to the theory, practice, and implementation of the Lattice Boltzmann (LB) method, a powerful computational fluid dynamics method that is steadily gaining attention due to its simplicity, scalability, extensibility, and simple handling of complex geometries. The book contains chapters on the method's background, fundamental theory, advanced extensions, and implementation. To aid beginners, the most essential paragraphs in each chapter are highlighted, and the introductory chapters on various LB topics are front-loaded with special "in a nutshell" sections that condense the chapter's most important practical results. Together, these sections can be used to quickly get up and running with the method. Exercises are integrated throughout the text, and frequently asked questions about the method are dealt with in a special section at the beginning. In the book itself and through its web page, readers can find example codes showing how the LB method can be implemented efficiently on a variety of hardware platforms, including multi-core processors, clusters, and graphics processing units. Students and scientists learning and using the LB method will appreciate the wealth of clearly presented and structured information in this volume.

Theory and Applications of the Lattice Boltzmann Method

A detailed description of lattice-gas hydrodynamics, including theory not presented in other books.

Lattice Boltzmann Method

Spanning biological, mathematical, computational, and engineering sciences, computational biofluiddynamics addresses a diverse family of problems involving fluid flow inside and around living organisms, organs, tissue, biological cells, and other biological materials. Computational Hydrodynamics of Capsules and Biological Cells provides a comprehensive, rigorous, and current introduction to the fundamental concepts, mathematical formulation, alternative approaches, and predictions of this evolving field. In the first several chapters on boundary-element, boundary-integral, and immersed-boundary methods, the book covers the flow-induced deformation of idealized two-dimensional red blood cells in Stokes flow, capsules with spherical unstressed shapes based on direct and variational formulations, and cellular flow in domains with complex geometry. It also presents simulations of microscopic hemodynamics and hemorheology as well as results on the deformation of capsules and cells in dilute and dense suspensions. The book then describes a discrete membrane model where a surface network of viscoelastic links emulates the spectrin network of the cytoskeleton, before presenting a novel two-dimensional model of red and white blood cell motion. The final chapter discusses the numerical simulation of platelet motion near a wall representing injured tissue. This volume provides a roadmap to the current state of the art in computational cellular mechanics and biofluiddynamics. It also indicates areas for further work on mathematical formulation and numerical implementation and identifies physiological problems that need to be addressed in future research. MATLAB® code and other data are available at http://dehesa.freeshell.org/CC2

Lattice Boltzmann Methods for Diffuse and Mobile Interfaces

The lattice Boltzmann method (LBM) is a modern numerical technique, very efficient, flexible to simulate different flows within complex/varying geome tries. It is evolved from the lattice gas automata (LGA) in order to overcome the difficulties with the LGA. The core equation in the LBM turns out to be a special discrete form of the continuum Boltzmann equation, leading it to be self-explanatory in statistical physics. The method describes the micro scopic picture of particles movement in an extremely simplified way, and on the macroscopic level it gives a correct average description of a fluid. The av eraged particle velocities behave in time and space just as the flow velocities in a physical fluid, showing a direct link between discrete microscopic and continuum macroscopic phenomena. In contrast to the traditional computational fluid dynamics (CFD) based on a direct solution of flow equations, the lattice Boltzmann method provides an indirect way for solution of the flow equations. The method is characterized by simple calculation, parallel process and easy implementation of boundary conditions. It is these features that make the lattice Boltzmann method a very promising computational method in different areas. In recent years, it receives extensive attentions and becomes a very potential research area in computational fluid dynamics. However, most published books are limited to the lattice Boltzmann methods for the Navier-Stokes equations. On the other hand, shallow water flows exist in many practical situations such as tidal flows, waves, open channel flows and dam-break flows.

Computational Many-Particle Physics

This volume in the series Lecture Notes in Computational Science and Engineering presents a collection of papers presented at the International Workshop on FSI, held in October 2005 in Hohenwart and organized by DFG's Research Unit 493 "FSI: Modeling, Simulation, and Optimization". The papers address partitioned and monolithic coupling approaches, methodical issues and applications, and discuss FSI from the mathematical, informatics, and engineering points of view.

Numerical Methods and Advanced Simulation in Biomechanics and Biological Processes

Flowing matter is all around us, from daily-life vital processes (breathing, blood circulation), to industrial, environmental, biological, and medical sciences. Complex states of flowing matter are equally present in fundamental physical processes, far remote from our direct senses, such as quantum-relativistic matter under ultra-high temperature conditions (quark-gluon plasmas). Capturing the complexities of such states of matter stands as one of the most prominent challenges of modern science, with multiple ramifications to physics, biology, mathematics, and computer science. As a result, mathematical and computational techniques capable of providing a quantitative account of the way that such complex states of flowing matter behave in space and time are becoming increasingly important. This book provides a unique description of a major technique, the Lattice Boltzmann method to accomplish this task. The Lattice Boltzmann method has gained a prominent role as an efficient computational tool for the numerical simulation of a wide variety of complex states of flowing matter across a broad range of scales; from fully-developed turbulence, to multiphase micro-flows, all the way down to nano-biofluidics and lately, even quantum-relativistic sub-nuclear fluids. After providing a self-contained introduction to the kinetic theory of fluids and a thorough account of its transcription to the lattice framework, this text provides a survey of the major developments which have led to the impressive growth of the Lattice Boltzmann across most walks of fluid dynamics and its interfaces with allied disciplines. Included are recent developments of Lattice Boltzmann methods for non-ideal fluids, micro- and nanofluidic flows with suspended bodies of assorted nature and extensions to strong non-equilibrium flows beyond the realm of continuum fluid mechanics. In the final part, it presents the extension of the Lattice Boltzmann method to quantum and relativistic matter, in an attempt to match the major surge of interest spurred by recent developments in the area of strongly interacting holographic fluids, such as electron flows in graphene.

Numerical Solution of Partial Differential Equations on Parallel Computers

Important developments in the progress of the theory of rock mechanics during recent years are based on fractals and damage mechanics. The concept of fractals has proved to be a useful way of describing the statistics of naturally occurring geometrics. Natural objects, from mountains and coastlines to clouds and forests, are found to have boundaries best described as fractals. Fluid flow through jointed rock masses and clusterings of earthquakes are found to follow fractal patterns in time and space. Fracturing in rocks at all scales, from the microscale (microcracks) to the continental scale (megafaults), can lead to fractal structures. The process of diagenesis and pore geometry of sedimentary rock can be quantitatively described by fractals, etc. The book is mainly concerned with these developments, as related to fractal descriptions of fragmentations, damage and fracture of rocks, rock burst, joint roughness, rock porosity and permeability, rock grain growth, rock and soil particles, shear slips, fluid flow through jointed rocks, faults, earthquake clustering, and so on. The prime concerns of the book are to give a simple account of the basic concepts, methods of fractal geometry, and their applications to rock mechanics, geology, and seismology, and also to discuss damage mechanics of rocks and its application to mining engineering. The book can be used as a textbook for graduate students, by university teachers to prepare courses and seminars, and by active scientists who want to become familiar with a fascinating new field.

Lattice Boltzmann And Gas Kinetic Flux Solvers: Theory And Applications

This volume presents the results of Computational Fluid Dynamics (CFD) analysis that can be used for conceptual studies of product design, detail product development, process troubleshooting. It demonstrates the benefit of CFD modeling as a cost saving, timely, safe and easy to scale-up methodology.

Lattice Boltzmann Method

The Axial Offset Anomaly (AOA) is a major impediment to increases in reactor fuel performance preventing PWRs from operating with even more efficient core designs than they are at present. It is a phenomenon where boron compounds such as lithium-metaborate and nickel-boroferrite concentrate and precipitate during reactor operation in corrosion products deposited on high-duty fuel assemblies at subcooled nucleate boiling conditions and cause the reactor neutron flux and core axial power distribution to deviate from the predicted distribution. The purpose of the present work is to describe the fundamentals in CRUD formation, transport, and deposition, in order to provide a theoretical basis for evaluating and analysing any fuel operational problem due to CRUD deposits. A Lattice Boltzmann Method model is proposed for simulating thermal hydraulic and chemical conditions in the coolant and the formation process of the CRUD.

The Lattice Boltzmann Equation

Progress in Computational Physics is an e-book series devoted to recent research trends in computational physics. It contains chapters contributed by outstanding experts of modeling of physical problems. The series focuses on interdisciplinary computational perspectives of current physical challenges, new numerical techniques for the solution of mathematical wave equations and describes certain real-world applications. With the help of powerful computers and sophisticated methods of numerical mathematics it is possible to simulate many ultramodern devices, e.g. photonic crystals structures, semiconductor nanostructures or fuel cell stacks devices, thus preventing expensive and longstanding design and optimization in the laboratories. In this book series, research manuscripts are shortened as single chapters and focus on one hot topic per volume. Engineers, physicists, meteorologists, etc. and applied mathematicians can benefit from the series content. Readers will get a deep and active insight into state-of-the art modeling and simulation techniques of ultra-modern devices and problems. The third volume - Novel Trends in Lattice Boltzmann Methods - Reactive Flow, Physicochemical Transport and Fluid-Structure Interaction - contains 10 chapters devoted to mathematical analysis of different issues related to the lattice Boltzmann methods, advanced numerical techniques for physico-chemical flows, fluid structure interaction and practical applications of these phenomena to real world problems.

Lagrangian Oceanography

Since the dawn of computing, the quest for a better understanding of Nature has been a driving force for technological development. Groundbreaking achievements by great scientists have paved the way from the abacus to the supercomputing power of today. When trying to replicate Nature in the computer's silicon test tube, there is need for precise and computable process descriptions. The scienti?c ?elds of Ma- ematics and Physics provide a powerful vehicle for such descriptions in terms of Partial Differential Equations (PDEs). Formulated as such equations, physical laws can become subject to computational and analytical studies. In the computational setting, the equations can be discreti ed for ef?cient solution on a computer, leading to valuable tools for simulation of natural and man-made processes. Numerical so- tion of PDE-based mathematical models has been an important research topic over centuries, and will remain so for centuries to come. In the context of computer-based simulations, the quality of the computed results is directly connected to the model's complexity and the number of data points used for the computations. Therefore, computational scientists tend to ?ll even the largest and most powerful computers they can get access to, either by increasing the si e of the data sets, or by introducing new model terms that make the simulations more realistic, or a combination of both. Today, many important simulation problems can not be solved by one single computer, but calls for parallel computing.

Theory of the Lattice Boltzmann Method: Dispersion, Dissipation, Isotropy, Galilean Invariance, and Stability

This volume focuses on progress in applying the lattice gas approach to partial differential equations that arise in simulating the flow of fluids.Lattice gas methods are new parallel, high-resolution, high-efficiency techniques for solving partial differential equations. This volume focuses on progress in applying the lattice gas approach to partial differential equations that arise in simulating the flow of fluids. It introduces the lattice Boltzmann equation, a new direction in lattice gas research that considerably reduces fluctuations.The twenty-seven contributions explore the many available software options exploiting the fact that lattice gas methods are completely parallel, which produces significant gains in speed. Following an overview of work done in the past five years and a discussion of frontiers, the chapters describe viscosity modeling and hydrodynamic mode analyses, multiphase flows and porous media, reactions and diffusion, basic relations and long-time correlations, the lattice Boltzmann equation, computer hardware, and lattice gas applications.Gary D. Doolen is Acting Director of the Center for Nonlinear Studies at Los Alamos National Laboratory.

Fluid-Structure Interaction

Here is a basic introduction to Lattice Boltzmann models that emphasizes intuition and simplistic conceptualization of processes, while avoiding the complex mathematics that underlies LB models. The model is viewed from a particle perspective where collisions, streaming, and particle-particle/particle-surface interactions constitute the entire conceptual framework. Beginners and those whose interest is in model application over detailed mathematics will find this a powerful 'quick start' guide. Example simulations, exercises, and computer codes are included.

Lattice Boltzmann Modeling

This self-contained book is an up-to-date description of the basic theory of molecular gas dynamics and its various applications. The book, unique in the literature, presents working knowledge, theory, techniques, and typical phenomena in rarefied gases for theoretical development and application. Basic theory is developed in a systematic way and presented in a form easily applied for practical use. In this work, the ghost effect and non-Navier–Stokes effects are demonstrated for typical examples—Bénard and Taylor–Couette problems—in the context of a new framework. A new type of ghost effect is also discussed.

Progress in Hybrid RANS-LES Modelling

A self-contained, comprehensive introduction to the theory of hydrodynamic lattice gases.

Progress in Computational Physics Volume 3: Novel Trends in Lattice-Boltzmann Methods

Lattice-gas cellular automata (LGCA) and lattice Boltzmann models (LBM) are relatively new and promising methods for the numerical solution of nonlinear partial differential equations. The book provides an introduction for graduate students and researchers. Working knowledge of calculus is required and experience in PDEs and fluid dynamics is recommended. Some peculiarities of cellular automata are outlined in Chapter 2. The properties of various LGCA and special coding techniques are discussed in Chapter 3. Concepts from statistical mechanics (Chapter 4) provide the necessary theoretical background for LGCA and LBM. The properties of lattice Boltzmann models and a method for their construction are presented in Chapter 5.

Lattice Boltzmann Modeling of Complex Flows for Engineering Applications

Multiphase Lattice Boltzmann Methods

Numerical Methods and Advanced Simulation in Biomechanics and Biological Processes covers new and exciting modeling methods to help bioengineers tackle problems for which the Finite Element Method is not appropriate. The book covers a wide range of important subjects in the field of numerical methods applied to biomechanics, including bone biomechanics, tissue and cell mechanics, 3D printing, computer assisted surgery and fluid dynamics. Modeling strategies, technology and approaches are continuously evolving as the knowledge of biological processes increases. Both theory and applications are covered, making this an ideal book for researchers, students and R&D professionals. Provides non-conventional analysis methods for modeling Covers the Discrete Element Method (DEM), Particle Methods (PM), MessLess and MeshFree Methods (MLMF), Agent-Based Methods (ABM), Lattice-Boltzmann Methods (LBM) and Boundary Integral Methods (BIM) Includes contributions from several world renowned experts in their fields Compares pros and cons of each method to help you decide which method is most applicable to solving specific problems