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Daniel T. Thorne, Jr.

Lattice Boltzmann Modeling

An Introduction
for Geoscientists
and Engineers



Springer

Lattice Boltzmann Modeling An Introduction For Geoscientists And Engineers

Timm Krüger



Lattice Boltzmann Modeling An Introduction For Geoscientists And Engineers:

Lattice Boltzmann Modeling Michael C. Sukop, Daniel T. Thorne, 2007-04-05 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 Michael C. Sukop, 2007 *Lattice Boltzmann Method And Its Application In Engineering* Zhaoli Guo, Chang Shu, 2013-03-25 Lattice Boltzmann method LBM is a relatively new simulation technique for the modeling of complex fluid systems and has attracted interest from researchers in computational physics Unlike the traditional CFD methods which solve the conservation equations of macroscopic properties i e mass momentum and energy numerically LBM models the fluid consisting of fictive particles and such particles perform consecutive propagation and collision processes over a discrete lattice mesh This book will cover the fundamental and practical application of LBM The first part of the book consists of three chapters starting from the theory of LBM basic models initial and boundary conditions theoretical analysis to improved models The second part of the book consists of six chapters address applications of LBM in various aspects of computational fluid dynamic engineering covering areas such as thermo hydrodynamics compressible flows multicomponent multiphase flows microscale flows flows in porous media turbulent flows and suspensions With these coverage LBM the book intended to promote its applications instead of the traditional computational fluid dynamic method

Fuel Cell Modeling and Simulation Gholam Reza Molaeimanesh, Farschad Torabi, 2022-11-12 Fuel Cell Modeling and Simulation From Micro Scale to Macro Scale provides a comprehensive guide to the numerical model and simulation of fuel cell systems and related devices with easy to follow instructions to help optimize analysis design and control With a focus on commercialized PEM and solid oxide fuel cells the book provides decision making tools for each stage of the modeling process including required accuracy and available computational capacity Readers are guided through the process of developing bespoke fuel cell models for their specific needs This book provides a step by step guide to the fundamentals of fuel cell modeling that is ideal for students researchers and industry engineers working with fuel cell systems but it will also be a great repository of knowledge for those involved with electric vehicles batteries and computational fluid dynamics Offers step by step guidance on the simulation of PEMFC and SOFC Provides an appendix of source codes for modeling simulation and optimization algorithms Addresses the fundamental thermodynamics and reaction kinetics of fuel cells fuel cell electric vehicles FCEVs and fuel cell power plant chapters

Computer Simulation Study of Collective Phenomena in Dense Suspensions of Red Blood Cells under Shear Timm Krüger, 2012-10-02 The rheology of dense red blood cell suspensions is investigated via computer simulations based on

the lattice Boltzmann the immersed boundary and the finite element methods The red blood cells are treated as extended and deformable particles immersed in the ambient fluid In the first part of the work the numerical model and strategies for stress evaluation are discussed In the second part the behavior of the suspensions in simple shear flow is studied for different volume fractions particle deformabilities and shear rates Shear thinning behavior is recovered The existence of a shear induced transition from a tumbling to a tank treading motion is demonstrated The transition can be parameterized by a single quantity namely the effective capillary number It is the ratio of the suspension stress and the characteristic particle membrane stress At the transition point a strong increase in the orientational order of the red blood cells and a significant decrease of the particle diffusivity are observed However the average cell deformation shows no signature of the transition

Multiphase Lattice Boltzmann Methods Haibo Huang, Michael Sukop, Xiyun Lu, 2015-06-08 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

Flow and Transport Properties of Unconventional Reservoirs 2018 Jianchao Cai, Zhien Zhang, Qinjun Kang, Harpreet Singh, 2019-07-23 Unconventional reservoirs are usually complex and highly heterogeneous such as shale coal and tight sandstone reservoirs The strong physical and chemical interactions between fluids and pore surfaces lead to the inapplicability of conventional approaches for characterizing fluid flow in these low porosity and ultralow permeability reservoir systems Therefore new theories and techniques are urgently needed to characterize petrophysical properties fluid transport and their relationships at multiple scales for improving production efficiency from unconventional reservoirs This book presents fundamental innovations gathered from 21 recent works on novel applications of new techniques and theories in unconventional reservoirs covering the fields of petrophysical characterization hydraulic fracturing fluid transport physics enhanced oil recovery and geothermal energy Clearly the research covered in this book is helpful to understand and master the latest techniques and theories for unconventional reservoirs which have important practical significance for the economic

and effective development of unconventional oil and gas resources *Lattice Boltzmann Modeling for Chemical Engineering*, 2020-06-19 Lattice Boltzmann Modeling for Chemical Engineering Volume 56 in the Advances in Chemical Engineering series highlights new advances in the field with this new volume presenting interesting chapters on Simulations of homogeneous and heterogeneous chemical reactions LBM for 3D Chemical Reactors LBM Simulations of PEM fuel cells LBM for separation processes LBM for two phase flow bio reactors and more Provides the authority and expertise of leading contributors from an international board of authors Presents the latest release in the Advances in Chemical Engineering series Includes the latest information on Lattice Boltzmann Modeling for Chemical Engineering Geomechanics for Energy and a Sustainable Environment Gye-Chun Cho, Ilhan Chang, 2020-01-23 This book describes recent advances in geomechanics for energy and the sustainable environment Four research articles related to high level radioactive nuclear waste disposal stability geological effect and wellbore stability considerations for methane gas hydrate production and artificial soil freezing are presented in this book In addition a comprehensive state of the art review verifies the strong correlation between global climate change and the occurrence of geotechnical engineering hazards The review also summarizes recent attempts to reduce CO₂ emissions from civil and geotechnical engineering practices Readers will gain ideas as to how we can deal with conventional and renewable energy sources and environment related geotechnical engineering issues **Large-Eddy Simulation Based on the Lattice Boltzmann Method for Built Environment Problems** Mengtao Han, Ryoza Ooka, 2023-05-29 This book details the lattice Boltzmann method LBM applied to the built environment problems It provides the fundamental theoretical knowledge and specific implementation methods of LBM from the engineering perspective of the built environment It covers comprehensive issues of built environment with three detailed cases solving practical problems It can be used as a reference book for teachers students and engineering technicians to study LBM and conduct architecture and urban wind environments simulations in the fields of architecture building technology science urban planning HVAC built environment engineering and civil engineering **Parallel Computing Technologies** Victor Malyshev, 2009-08-04 This book constitutes the proceedings of the 10th International Conference on Parallel Computing Technologies PaCT 2009 held in Novosibirsk Russia on August 31 September 4 2009 The 34 full papers presented together with 2 invited papers and 7 poster papers were carefully reviewed and selected from 72 submissions The papers are organized in topical sections on models of parallel computing methods and algorithms fine grained parallelism parallel programming tools and support and applications Multiscale and Multiphysics Flow Simulations of Using the Boltzmann Equation Jun Li, 2019-08-28 This book provides a comprehensive introduction to the kinetic theory for describing flow problems from molecular scale hydrodynamic scale to Darcy scale The author presents various numerical algorithms to solve the same Boltzmann like equation for different applications of different scales in which the dominant transport mechanisms may differ This book presents a concise introduction to the Boltzmann equation of the kinetic theory based on which different simulation methods that were

independently developed for solving problems of different fields can be naturally related to each other Then the advantages and disadvantages of different methods will be discussed with reference to each other It mainly covers four advanced simulation methods based on the Boltzmann equation i e direct simulation Monte Carlo method direct simulation BGK method discrete velocity method and lattice Boltzmann method and their applications with detailed results In particular many simulations are included to demonstrate the applications for both conventional and unconventional reservoirs With the development of high resolution CT and high performance computing facilities the study of digital rock physics is becoming increasingly important for understanding the mechanisms of enhanced oil and gas recovery The advanced methods presented here have broad applications in petroleum engineering as well as mechanical engineering making them of interest to researchers professionals and graduate students alike At the same time instructors can use the codes at the end of the book to help their students implement the advanced technology in solving real industrial problems

Introduction to Environmental Modeling William G. Gray, Genetha A. Gray, 2017 This textbook presents the timeless basic physical and mathematical principles and philosophy of environmental modeling to students who need to be taught how to think in a different way than they would for more narrowly defined engineering or physics problems Examples come from a range of hydrologic atmospheric and geophysical problems

Introduction to Numerical Modeling in the Earth and Planetary Sciences Christian Huber, 2025-07-17 This textbook provides an introduction to the world of numerical modeling in the physical sciences focusing more specifically on earth and planetary sciences It is designed to lead the reader through the process of defining the mathematical or physical model of interest and applying numerical methods to approximate and explore the solutions to these models while also providing a quantitative assessment of the limitations performance and quality of these approximations The book is designed to provide a self contained reference by including the mathematical foundations required to understand the models and their convergence It includes a detailed discussion of models for ordinary systems of equation and partial differential equations with pseudo codes detailing the solution procedure Examples are drawn from the fields of earth and planetary sciences including geochemical box models non linear ordinary differential equations describing the evolution of subvolcanic magma chambers the mass conservation of cosmogenic nuclides in soils diffusion in minerals the hillslope equation the advection diffusion and wave equations and the shallow water equations Featuring numerous examples drawn from earth and planetary sciences the content of this book has been used by the author to teach numerical methods classes at the undergraduate and graduate levels over several years and will provide an excellent resources for teachers and learners in this area

Fluid Mechanics and Fluid Power - Contemporary Research Arun K. Saha, Debopam Das, Rajesh Srivastava, P. K. Panigrahi, K. Muralidhar, 2016-09-20 This volume comprises the proceedings of the 42nd National and 5th International Conference on Fluid Mechanics and Fluid Power held at IIT Kanpur in December 2014 The conference proceedings encapsulate the best deliberations held during the conference The diversity of

participation in the conference from academia industry and research laboratories reflects in the articles appearing in the volume This contributed volume has articles from authors who have participated in the conference on thematic areas such as Fundamental Issues and Perspectives in Fluid Mechanics Measurement Techniques and Instrumentation Computational Fluid Dynamics Instability Transition and Turbulence Turbomachinery Multiphase Flows Fluid Structure Interaction and Flow Induced Noise Microfluidics Bio inspired Fluid Mechanics Internal Combustion Engines and Gas Turbines and Specialized Topics The contents of this volume will prove useful to researchers from industry and academia alike Unconventional Hydrocarbon Resources Reza Barati, Mustafa M. Alhubail, 2020-11-11 A comprehensive textbook presenting techniques for the analysis and characterization of shale plays Significant reserves of hydrocarbons cannot be extracted using conventional methods Improvements in techniques such as horizontal drilling and hydraulic fracturing have increased access to unconventional hydrocarbon resources ushering in the shale boom and disrupting the energy sector Unconventional Hydrocarbon Resources Techniques for Reservoir Engineering Analysis covers the geochemistry petrophysics geomechanics and economics of unconventional shale oil plays The text uses a step by step approach to demonstrate industry standard workflows for calculating resource volume and optimizing the extraction process Volume highlights include Methods for rock and fluid characterization of unconventional shale plays A workflow for analyzing wells with stimulated reservoir volume regions An unconventional approach to understanding of fluid flow through porous media A comprehensive summary of discoveries of massive shale resources worldwide Data from Eagle Ford Woodford Wolfcamp and The Bakken shale plays Examples homework assignments projects and access to supplementary online resources Hands on teaching materials for use in petroleum engineering software applications The American Geophysical Union promotes discovery in Earth and space science for the benefit of humanity Its publications disseminate scientific knowledge and provide resources for researchers students and professionals **Analysis and Applications of Lattice Boltzmann Simulations** Valero-Lara, Pedro, 2018-05-04 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 *Computational Fluid Dynamics* Guoxiang Hou, Caikan Chen, Shenglei Qin, Yuan Gao, Kai Wang, 2024-04-30 This book provides a concise and comprehensive introduction to several basic methods with more attention to their theoretical basis and applications in fluid dynamics Furthermore some new ideas are presented in this book for example a method to

solve the transition matrix by difference operator transformation For this method the book gives the definition of Fourier integral transformation of translation operator and proves the transition matrix equaling to the differential operator transformation so that it is extended to general situations of explicit implicit multi layer difference equations etc This flexible approach is also used in the differential part In addition the book also includes six types of equivalent stability definitions in two ways and deeply analyzes their errors stabilities and convergences of the difference equations What is more important some new scientific contributions on lattice Boltzmann method LBM in recent years are presented in the book as well The authors write the book combining their ten years teaching experience and research results and this book is intended for graduate students who are interested in the area of computational fluid dynamics CFD Authors list some new research achievements such as simplified lattice Boltzmann method the simplified lattice Boltzmann flux solver and discrete unified gas kinetic scheme and expect that this new information could give readers possible further investigating ideas in their future research on CFD area

Computational Analysis of Transport Phenomena and Performance of PEMFC Bengt Sundén, Shian Li, Fereshteh Salimi Nanadegani, 2025-08-01 Computational Analysis of Transport Phenomena and Performance of PEMFC presents a practical guide to the mathematical modeling and simulation of PEMFCs for all transport processes of mass momentum energy ions and electrons Tackling one of the most important aspects of next generation PEMFC technologies the book brings together the state of the art to model and simulate phenomena and processes at various scales including catalyst layers electrodes membranes and bipolar plates of PEMFC unit cells and stacks Chapters introduce PEM fuel cells and explain the underlying electrochemical and thermodynamic concepts involved present a detailed breakdown of the governing equations for overall mass momentum and energy conservation charge ions and electrons conservation water generation and its transport heat generation and heat transfer and cooling methods offer an in depth analysis of the various single and multi dimensional modelling approaches and considerations including lattice Boltzmann approach artificial neural networks exergy and energy analysis estimation of fuel and oxidant consumption the differences between cell scale stack scale and system scale approaches and more Explains modeling transport phenomena and performance at multiple levels Discusses the unique characteristics of modeling phenomena in the various layers and at various scales in PEM fuel cells alongside formulations and necessary sub models Highlights the limitations and opportunities for machine learning approaches as well as exergy and energy analysis Provides numerically solved examples to illustrate modeling approaches

Bioreactors for Microbial Biomass and Energy Conversion Qiang Liao, Jo-shu Chang, Christiane Herrmann, Ao Xia, 2018-04-20 This book discusses recent trends and developments in the microbial conversion process which serves as an important route for biofuel production with particular attention to bioreactors It combines microbial conversion with multiphase flow and mass transfer providing an alternative perspective for the understanding of microbial biomass and energy production process as well as enhancement strategy This book is relevant to students and researchers who work in

the fields of renewable energy engineering and biotechnology Policymakers economists and industry engineers also benefit from this book as it can be used as a resource for the implementation of renewable energy technologies

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