The Lattice Boltzmann Equation For Fluid Dynamics And Beyond Numerical Mathematics And Scientific Computation By Succi Sauro 2013 Paperback

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Introduction to the Lattice Boltzmann Method

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Inpainting by Modified Lattice Boltzmann Method and Exemplar Method for Object Removal in Colour*Kinetic-based Multiphase Flow Simulation* Plenary talk - Alessandro Gabbana - Relativistic Lattice Boltzmann Methods: Theory and Applications *PISACMS 2015 - Benjamin Rotenberg - Lattice-Boltzmann methods*

The Lattice Boltzmann Equation For

In recent years, certain forms of the Boltzmann equation--now going by the name of "Lattice Boltzmann equation" (LBE)--have emerged which relinquish most mathematical complexities of the true Boltzmann equation without sacrificing physical fidelity in the description of complex fluid motion.

The Lattice Boltzmann Equation for Fluid Dynamics and ...

Speeds in lattice Boltzmann simulations are typically given in terms of the speed of sound. The discrete time unit can therefore be given as. ? t = ? x C s.

{\displaystyle \delta _ {t}= {\frac {\delta _ {x}} {C_ {s}}}\,\!} , where the denominator. C s. {\displaystyle C_ {s}} is the physical speed of sound.

Lattice Boltzmann methods - Wikipedia

The Lattice Boltzmann Equation for Fluid Dynamics and Beyond (Numerical Mathematics and Scientific Computation)

The Lattice Boltzmann Equation: For Complex States of ...

The Boltzmann equation or Boltzmann transport equation (BTE) describes the statistical behaviour of a thermodynamic system not in a state of equilibrium, devised by Ludwig Boltzmann in 1872. The classic example of such a system is a fluid with temperature gradients in space causing heat to flow from hotter regions to colder ones, by the random but biased transport of the particles making up ...

Boltzmann equation - Wikipedia

The Lattice Boltzmann method is relatively new. The Method of lattice Boltzmann equation (LBE) is an innovative numerical method based on kinetic theory to simulate various hydrodynamic systems. The lattice Boltzmann equation was introduced to overcome some serious deficiencies of its historic predecessor: the lattice gas automata.

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lattice Boltzmann Method for CFD

The Lattice Boltzmann Equation for Fluid Dynamics and Beyond (Numerical Mathematics and Scientific Computation) Sauro Succi. 4.3 out of 5 stars 5. Hardcover. $175.00. Only 6 left in stock (more on the way). Multiphase Lattice Boltzmann Methods: Theory and Application Haibo Huang.

The Lattice Boltzmann Equation For Fluid Dynamics And ...

Abstract. A simple lattice Boltzmann equation (LBE) model for axisymmetric thermal flow is proposed in this paper. The flow field is solved by a quasi-two-dimensional nine-speed (D2Q9) LBE, while the temperature field is solved by another four-speed (D2Q4) LBE. The model is validated by a thermal flow in a pipe and some nontrivial thermal buoyancy-driven flows in vertical cylinders, including Rayleigh–Bénard convection, natural convection, and heat transfer of swirling flows.

Lattice Boltzmann equation for axisymmetric thermal flows ...

This work combines the lattice Boltzmann equation (LBE) and the overset method to simulate moving boundary problems in Navier-Stokes flows in two dimensions (2D). The transformation of the velocity moments of the distribution functions between a moving frame of reference and the one at rest is analyzed.

Lattice Boltzmann equation with Overset method for moving ...

This paper proposes an optimal two-relaxation-time (OTRT) lattice Boltzmann equation (LBE) for solid-liquid phase change. By using the Chapman-Enskog expansion, the OTRT LBE can recover the enthalpy-based energy governing equation up to second-order accuracy.

An optimal two-relaxation-time lattice Boltzmann equation ...

We define the lattice Boltzmann equation in three dimensions as: (1) f i j k (x + i c ? t) (y + j c ? t) (z + k c ? t) (t + ? t) = f i j k x y z t + ? i j k x y z t = f i j k x y z t ?. Here i c , j c , and k c refer to the variables in momentum space with c being the velocity quantum and i , j , k ? Z , x , y , and z are the variables in space and t is the time variable.

The cumulant lattice Boltzmann equation in three ...

It is shown that the lattice Boltzmann equation is a special discretized form of the Boltzmann equation. Various approximations for the discretization of the Boltzmann equation in both time and phase space are discussed in detail. A general procedure to derive the lattice Boltzmann model from the continuous Boltzmann equation is demonstrated explicitly.

Theory of the lattice Boltzmann method: From the Boltzmann ...

The lattice Boltzmann equation (LBE) is directly derived from the Boltzmann equation by discretization in both time and phase space. A procedure to systematically derive discrete velocity models is presented. A LBE algorithm with arbitrary mesh grids is proposed and a numerical simulation of the backward-facing step is conducted.

A priori derivation of the lattice Boltzmann equation ...

2 Reviews In recent years, stylized forms of the Boltzmann equation, now going by the name of "Lattice Boltzmann equation" (LBE), have emerged, which relinquish most mathematical complexities of...

The Lattice Boltzmann Equation: For Fluid Dynamics and ...

The Lattice Boltzmann Equation for Fluid Dynamics and Beyond. Sauro Succi. A Clarendon Press Publication. Numerical Mathematics and Scientific Computation. Description. In recent years, certain forms of the Boltzmann equation--now going by the name of "Lattice Boltzmann equation" (LBE)--have emerged which relinquish most mathematical complexities of the true Boltzmann equation without sacrificing physical fidelity in the description of complex fluid motion.

The Lattice Boltzmann Equation for Fluid Dynamics and ...

In this paper, the lattice Boltzmann equation is directly derived from the Boltzmann equation. It is shown that the lattice Boltzmann equation is a special discretized form of the Boltzmann...

PDF Theory of the lattice Boltzmann method: From the ...

The Lattice Boltzmann equation: mathematical formulation. The lattice Boltzmann equation reads as follows (Wolf-Gladrow, 2000; Succi, 2001) \[\tag{2} f_i(\vec{r} +{\vec{c}}_i \Delta t, t+\Delta t) = f_i(\vec{r};t) + \Omega_{ij} (f^{eq}_j(\vec{r};t)-f_j(\vec{r};t)) \]

Lattice Boltzmann Method - Scholarpedia

As a type of numerical method for fluid flows, the lattice Boltzmann equation (LBE) method has gained much success in a variety of complex flows, and certain OBCs have been suggested for the LBE in...

(PDF) Evaluation of outflow boundary conditions for two ...

Over the past near three decades, the Lattice Boltzmann method has gained a prominent role as an efficient computational method 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 subnuclear fluids.

Lattice Boltzmann Equation: For Complex States of Flowing ...

Lattice Boltzmann Method Implementation To implement the LBM method, we separate the solution of the equation fi(x + ei?t, t + ?t) ? fi(x, t) = ?i(t). into two steps, referred to as streaming and collision steps. This approach is somewhat analogous to the common splitting mechanism used in solutions to the Navier-Stokes equations.

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.

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.

The Lattice Boltzmann Method (LBM) is a powerful technique for the computation of a wide variety of complex fluid flow problems including single and multiphase fluids in complex geometries. Historically, the Lattice Boltzmann equation for modeling hydrodynamics originated from the lattice gas cellular automata (LGCA), which are discrete models based on particles that move on a lattice. The LBM is different from traditional computational fluid dynamics (CFD) approaches, which solve the Navier-Stokes equations numerically. The LBM models the fluid with particle distributions, and assumes that these particles perform collision and steaming processes on a discrete lattice mesh. During the last decade, the LBM has been receiving increased attention. Great improvements have occurred not only in theoretical understanding but also in algorithmic development, and the method has been used more widely in computational fluid dynamics. The LBM are explicit time-integration approaches which are based on the Lattice Boltzmann Equation (LBE). They are notoriously inefficient for steady-state simulations or time-dependent problems which have large separations in relevant time and spatial scales. To solve this problem, a time-implicit multigrid LBE scheme is developed in this work. This scheme can solve the time dependent LBE problem more efficiently by using unconditionally large time step sizes. The improved efficiency and temporal accuracy of this implicit multigrid LBE scheme are demonstrated by numerical experiments and comparisons with the original explicit LBE approach.

The first detailed survey of the Lattice Boltzmann Equation theory and its major applications to date. This book is accessible to a range of scientists dealing with complex system dynamics, the book also portrays future developments in allied areas of science (material science, biology etc.) where fluid motion plays a distinguished role.

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.

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

In this dissertation, we explore direct-forcing immersed boundary methods (IBM) under the framework of the lattice Boltzmann method (LBM), which is called the direct-forcing immersed boundary-lattice Boltzmann method (IB-LBM). First, we derive the direct-forcing formula based on the split-forcing lattice Boltzmann equation, which recovers the Navier-Stokes equation with second-order accuracy and enables us to develop a simple and accurate formula due to its kinetic nature. Then, we assess the various interface schemes under the derived direct-forcing formula. We consider not only diffuse interface schemes but also a sharp interface scheme. All tested schemes show a second-order overall accuracy. In the simulation of stationary complex boundary flows, we can observe that the sharper the interface scheme is, the more accurate the results are. The interface schemes are also applied to moving boundary problems. The sharp interface scheme shows better accuracy than the diffuse interface schemes but generates spurious oscillation in the boundary forcing terms due to the discontinuous change of nodes for the interpolation. In contrast, the diffuse interface schemes show smooth change in the boundary forcing terms but less accurate results because of discrete delta functions. Hence, the diffuse interface scheme with a corrected radius can be adopted to obtain both accurate and smooth results. Finally, a direct-forcing immersed boundary method (IBM) for the thermal lattice Boltzmann method (TLBM) is proposed to simulate non-isothermal flows. The direct-forcing IBM formulas for thermal equations are derived based on two TLBM models: a doublepopulation model with a simplified thermal lattice Boltzmann equation (Model 1) and a hybrid model with an advection-diffusion equation of temperature (Model 2). The proposed methods are validated through natural convection problems with stationary and moving boundaries. In terms of accuracy, the results obtained from the IBMs based on both models are comparable and show a good agreement with those from other numerical methods. In contrast, the IBM based on Model 2 is more numerically efficient than the IBM based on Model 1. Overall, this study serves to establish the feasibility of the direct-forcing IB-LBM as a viable tool for computing various complex and/or moving boundary flow problems.

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.

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.

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 form 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.