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BAKER AXEL

Mesoscopic Theories of Heat Transport in *Nanosystems* Springer Science & Business Media This Element presents a unified computational

fluid dynamics framework from rarefied to continuum regimes. The framework is based on the direct modelling of flow physics in a discretized space. The mesh size and time step are used as modelling scales in the construction of discretized governing equations. With the variation-of-cell Knudsen number, continuous modelling equations in different regimes have been obtained, and the Boltzmann and Navier-Stokes equations become two limiting equations in the kinetic and hydrodynamic scales. The unified algorithms include the discrete velocity method (DVM)–based unified gas-kinetic scheme (UGKS), the particlebased unified gas-kinetic particle method (UGKP), and the wave and particle–based unified gas-kinetic wave-particle method (UGKWP). The UGKWP is a multi-scale method with the particle for non-equilibrium transport and wave for equilibrium evolution. The particle dynamics in the rarefied regime and the hydrodynamic flow solver in the continuum regime have been unified according to the cell's Knudsen number.

Rational Extended Thermodynamics beyond the Monatomic Gas World Scientific Providing a clear description of the theory of polydisperse multiphase flows, with emphasis on the mesoscale modelling approach and its relationship with microscale and macroscale models, this all-inclusive introduction

is ideal whether you are working in industry or academia. Theory is linked to practice through discussions of key real-world cases (particle/droplet/bubble coalescence, break-up, nucleation, advection and diffusion and physical- and phase-space), providing valuable experience in simulating systems that can be applied to your own applications. Practical cases of QMOM, DQMOM, CQMOM, EQMOM and ECQMOM are also discussed and compared, as are realizable finite-volume methods. This provides the tools you need to use quadrature-based moment methods, choose from the many available options, and design high-order numerical methods that guarantee realizable moment sets. In addition to the numerous practical examples, MATLAB scripts for several algorithms are also provided, so you can apply the methods described to practical problems straight away.

A Modern Course in Transport Phenomena

Cambridge University Press

Many areas of physics research depend upon a good physical understanding of charged particle transport processes in gases, a statement which is as true now as it was in the early part of the last century, when modern physics was taking shape. Gas lasers, multi-wire drift chambers used in high energy particle detectors, muon-catalysed fusion in hydrogen and its isotopes and low-temperature plasma processing

technology are just a few examples of experiments and processes in which electrons, ions or muons play a key role. The macroscopic properties of these non-equilibrium systems can best be found by averaging microscopic collision properties over a velocity distribution function, calculated from solution of Boltzmann's kinetic equation, using recently developed techniques. This is the realm of the modern kinetic theory of gases, and is the theme of this book.

An Introduction to the Theory of the Boltzmann Equation BoD – Books on Demand

At the 19th Annual Conference on Parallel Computational Fluid Dynamics held in Antalya, Turkey, in May 2007, the most recent developments and implementations of large-scale and grid computing were presented. This book, comprised of the invited and selected papers of this conference, details those advances, which are of particular interest to CFD and CFD-related communities. It also offers the results related to applications of various scientific and engineering problems involving flows and flow-related topics. Intended for CFD researchers and graduate students, this book is a state-of-the-art presentation of the relevant methodology and implementation techniques of large-scale computing.

Numerical schemes for multi-species BGK equations based on a variational procedure Courier Corporation

This book presents generalized heat-conduction laws which, from a mesoscopic perspective, are relevant to new applications (especially in nanoscale heat transfer, nanoscale thermoelectric phenomena, and in diffusive-to-ballistic regime) and at the same time keep up with the pace of current microscopic research. The equations presented in the book are compatible with generalized formulations of nonequilibrium thermodynamics, going beyond the local-equilibrium. The book includes six main chapters, together with a preface and a final section devoted to the future perspectives, as well as an extensive bibliography.
Proceedings, "WASCOM 2007" Springer
The well known transport laws of Navier-Stokes and Fourier fail for the simulation of processes on lengthscales in the order of the mean free path of a particle that is when the Knudsen number is not small enough. Thus, the proper simulation of flows in rarefied gases requires a more detailed description. This book discusses classical and modern methods to derive macroscopic transport equations for rarefied gases from the Boltzmann equation, for small and moderate Knudsen numbers, i.e. at and above the Navier-Stokes-Fourier level. The main methods discussed are the classical Chapman-Enskog and Grad approaches, as well as the new order of magnitude

method, which avoids the short-comings of the classical methods, but retains their benefits. The relations between the various methods are carefully examined, and the resulting equations are compared and tested for a variety of standard problems. The book develops the topic starting from the basic description of an ideal gas, over the derivation of the Boltzmann equation, towards the various methods for deriving macroscopic transport equations, and the test problems which include stability of the equations, shock waves, and Couette flow.

Dispersive Transport Equations and Multiscale Models

Springer Science & Business Media

This book is a pedagogical presentation of the application of spectral and pseudospectral methods to kinetic theory and quantum mechanics. There are additional applications to astrophysics, engineering, biology and many other fields. The main objective of this book is to provide the basic concepts to enable the use of spectral and pseudospectral methods to solve problems in diverse fields of interest and to a wide audience. While spectral methods are generally based on Fourier Series or Chebychev polynomials, non-classical polynomials and associated quadratures are used for many of the applications presented in the book. Fourier series methods are summarized with a discussion of the resolution of the Gibbs

phenomenon. Classical and non-classical quadratures are used for the evaluation of integrals in reaction dynamics including nuclear fusion, radial integrals in density functional theory, in elastic scattering theory and other applications. The subject matter includes the calculation of transport coefficients in gases and other gas dynamical problems based on spectral and pseudospectral solutions of the Boltzmann equation. Radiative transfer in astrophysics and atmospheric science, and applications to space physics are discussed. The relaxation of initial non-equilibrium distributions to equilibrium for several different systems is studied with the Boltzmann and Fokker-Planck equations. The eigenvalue spectra of the linear operators in the Boltzmann, Fokker-Planck and Schrödinger equations are studied with spectral and pseudospectral methods based on non-classical orthogonal polynomials. The numerical methods referred to as the Discrete Ordinate Method, Differential Quadrature, the Quadrature Discretization Method, the Discrete Variable Representation, the Lagrange Mesh Method, and others are discussed and compared. MATLAB codes are provided for most of the numerical results reported in the book - see Link under 'Additional Information' on the the right-hand column.

The Physics of Phonons

Springer

The book collects relevant contributions presented at a conference, organized in honour of Carlo Cercignani, that took place at Politecnico di Milano on May 24–28, 2021. Different research areas characterizing the scientific work of Carlo Cercignani have been considered with a particular focus on: mathematical and numerical methods for kinetic equations; kinetic modelling of gas mixtures and polyatomic gases; applications of the Boltzmann equation to electron transport, social phenomena and epidemic spread; turbulence modelling; the Einstein Classical Program; Dynamical Systems Theory.

Applications of Chaos and Nonlinear Dynamics in Science and Engineering - Vol. 4 Springer

This introductory graduate-level text emphasizes physical aspects of the theory of Boltzmann's equation in a detailed presentation that doubles as a practical resource for professionals. 1971 edition.

Continuum Mechanics, Applied Mathematics and Scientific Computing: Godunov's Legacy Springer Science & Business Media

Model reduction and coarse-graining are important in many areas of science and engineering. How does a system with many degrees of freedom become one with fewer? How can a reversible micro-description be adapted to the dissipative macroscopic model? These crucial questions,

as well as many other related problems, are discussed in this book. All contributions are by experts whose specialities span a wide range of fields within science and engineering.

Relativistic Microscopic Quantum Transport Equation Springer

Appendix after each chapter

Computational Models for Polydisperse Particulate and Multiphase Systems Springer Nature

Chaos and nonlinear dynamics initially developed as a new emergent field with its foundation in physics and applied mathematics. The highly generic, interdisciplinary quality of the insights gained in the last few decades has spawned myriad applications in almost all branches of science and technology—and even well beyond. Wherever quantitative modeling and analysis of complex, nonlinear phenomena is required, chaos theory and its methods can play a key role. his fourth volume concentrates on reviewing further relevant contemporary applications of chaotic and nonlinear dynamics as they apply to the various cuttingedge branches of science and engineering. This encompasses, but is not limited to, topics such as synchronization in complex networks and chaotic circuits, time series analysis, ecological and biological patterns, stochastic control theory and vibrations in mechanical systems. Featuring contributions from active and leading

research groups, this collection is ideal both as a reference and as a ‘recipe book’ full of tried and tested, successful engineering applications.

Waves and Stability in Continuous Media MDPI

This book is a liber amicorum to Professor Sergei Konstantinovich Godunov and gathers contributions by renowned scientists in honor of his 90th birthday. The contributions address those fields that Professor Godunov is most famous for: differential and difference equations, partial differential equations, equations of mathematical physics, mathematical modeling, difference schemes, advanced computational methods for hyperbolic equations, computational methods for linear algebra, and mathematical problems in continuum mechanics.

Accuracy and Limits of Applicability of Solutions of Equations of Transport IGI Global

Computational fluid dynamics (CFD) studies the flow motion in a discretized space. Its basic scale resolved is the mesh size and time step. The CFD algorithm can be constructed through a direct modeling of flow motion in such a space. This book presents the principle of direct modeling for the CFD algorithm development, and the construction unified gas-kinetic scheme (UGKS). The UGKS accurately captures the gas evolution from rarefied to continuum flows. Numerically it provides a continuous spectrum of governing

equation in the whole flow regimes. Contents:Direct Modeling for Computational Fluid DynamicsIntroduction to Gas Kinetic TheoryIntroduction to Nonequilibrium Flow SimulationsGas Kinetic SchemeUnified Gas Kinetic SchemeLow Speed Microflow StudiesHigh Speed Flow StudiesUnified Gas Kinetic Scheme for Diatomic GasConclusion Readership: Undergraduate and graduate students, researchers and professionals interested in computational fluid dynamics. Key Features:Direct modeling for CFD is self-contained and unified in presentationIt may be used as an advanced textbook by graduate students and even ambitious undergraduates in computational fluid dynamicsIt is also suitable for experts in CFD who wish to have a new understanding of the fundamental problems in the subject and study alternative approaches in CFD algorithm development and applicationThe explanations in the book are detailed enough to capture the interest of the curious reader, and complete enough to provide the necessary background material needed to go further into the subject and explore the research literatureKeywords:Direct Modeling;Unified Gas Kinetic Scheme;Boltzmann Equation;Kinetic Collision Model;Asymptotic Preserving Method

Macroscopic Transport Equations for Rarefied

Gas Flows Springer Science & Business Media This book is dedicated to the recent developments in RET with the aim to explore polyatomic gas, dense gas and mixture of gases in non-equilibrium. In particular we present the theory of dense gases with 14 fields, which reduces to the Navier-Stokes Fourier classical theory in the parabolic limit. Molecular RET with an arbitrary number of field-variables for polyatomic gases is also discussed and the theory is proved to be perfectly compatible with the kinetic theory in which the distribution function depends on an extra variable that takes into account a molecule's internal degrees of freedom. Recent results on mixtures of gases with multi-temperature are presented together with a natural definition of the average temperature. The qualitative analysis and in particular, the existence of the global smooth solution and the convergence to equilibrium are also studied by taking into account the fact that the differential systems are symmetric hyperbolic. Applications to shock and sound waves are analyzed together with light scattering and heat conduction and the results are compared with experimental data. Rational extended thermodynamics (RET) is a thermodynamic theory that is applicable to non-equilibrium phenomena. It is described by differential hyperbolic systems of balance laws with local constitutive equations. As RET has been strictly

related to the kinetic theory through the closure method of moment hierarchy associated to the Boltzmann equation, the applicability range of the theory has been restricted within rarefied monatomic gases. The book represents a valuable resource for applied mathematicians, physicists and engineers, offering powerful models for potential applications like satellites reentering the atmosphere, semiconductors and nano-scale phenomena.

From Kinetic Theory to Turbulence Modeling
Cambridge University Press
This volume focuses on modeling processes for which transport is one of the most complicated components, requiring different transport models in each region. The authors apply questions to a wide variety of application areas, such as semiconductors, plasmas, fluids, chemically reactive gases, etc.

Spectral Methods in Chemistry and Physics
Springer Nature
Thermodynamics is one of the most exciting branches of physical chemistry which has greatly contributed to the modern science. Being concentrated on a wide range of applications of thermodynamics, this book gathers a series of contributions by the finest scientists in the world, gathered in an orderly manner. It can be used in post-graduate courses for students and as a reference book, as it is written in a language pleasing to the reader. It can also serve as a

reference material for researchers to whom the thermodynamics is one of the area of interest.

Theory and Application of the Boltzmann Equation

Springer

The violent dynamical expansion of dense matter produced in heavy-ion collisions determines that the microscopic transport theories designed for it should keep the line of time evolution and medium effects, both in the in-medium particle drifting and in-medium particle-particle scatterings. A set of relativistic transport equations for particle distribution functions have thus been developed. Starting from a Lagrangian of baryons interacting through mesons, one computes Feynman diagrams up to the Born term through employing the closed time-path Green's function technique. All the ingredients of equations are derived from the same effective interaction and presented analytically. This book clearly shows how a relativistic Boltzmann equation can be deduced from a given interaction through reckoning Feynman diagrams of quantum field theory. While discussions are concentrated on the topic of relativistic heavy-ion collisions, the introduced method is rather general, and may find it's application in the problems of neutrino transportation of astrophysics and electron transportation of solid-state physics.

Model Reduction and Coarse-Graining

Approaches for Multiscale Phenomena
Cambridge University Press
This book provides general guidelines for solving thermal problems in the fields of engineering and natural sciences. Written for a wide audience, from beginner to senior engineers and physicists, it provides a comprehensive framework covering theory and practice and including numerous fundamental and real-world examples. Based on the thermodynamics of various material laws, it focuses on the mathematical structure of the continuum models and their experimental validation. In addition to several examples in renewable energy, it also presents thermal processes in space, and summarizes size-dependent, non-Fourier, and non-Fickian problems, which have increasing practical relevance in, e.g., the semiconductor industry. Lastly, the book discusses the key aspects of numerical methods, particularly highlighting the role of boundary conditions in the modeling process. The book provides readers with a comprehensive toolbox, addressing a wide variety of topics in thermal modeling, from constructing material laws to designing advanced power plants and engineering systems.

Emerging Applications of Plasma Science in Allied Technologies
Springer Science & Business Media
This fully updated second edition of The Physics of

Phonons remains the most comprehensive theoretical discussion devoted to the study of phonons, a major area of condensed matter physics. It contains exciting new sections on phonon-related properties of solid surfaces, atomically thin materials (such as graphene and monolayer transition metal chalcogenides), in addition to nano-structures and nanocomposites, thermoelectric nanomaterials, and topological nanomaterials, with an entirely new chapter dedicated to topological nanophononics and chiralphononics. Although primarily theoretical in approach, the author refers to experimental results wherever possible, ensuring an ideal book for both experimental and theoretical researchers. The author begins with an introduction to crystal symmetry and continues with a discussion of lattice dynamics in the harmonic approximation, including the traditional phenomenological approach and the more recent ab initio approach, detailed for the first time in this book. A discussion of anharmonicity is followed by the theory of lattice thermal conductivity, presented at a level far beyond that available in any other book. The chapter on phonon interactions is likewise more comprehensive than any similar discussion elsewhere. The sections on phonons in superlattices, impure and mixed crystals, quasicrystals, phonon

spectroscopy, Kapitza resistance, and quantum evaporation also contain material appearing in book form for the first time. The book is complemented by numerous diagrams that aid understanding and is comprehensively referenced for further study. With its unprecedented wide coverage of the field, The Physics of Phonons is an indispensable guide for advanced undergraduates, postgraduates, and researchers working in condensed matter physics and materials science. Features Fully updated throughout, with exciting new coverage on graphene, nanostructures and nanocomposites, thermoelectric nanomaterials, and topological nanomaterials. Authored by an authority on phonons. Interdisciplinary, with broad applications through condensed matter physics, nanoscience, and materials science. --