Foreword

The lecture series *Discrete Simulation of Fluid Dynamics (DSFD)* began in 1986 in Los Alamos thanks to Gary D. Doolens initiative. Since then, this annual conference has allowed researchers to take stock of the progress being made in fluid mechanics simulation using kinetic methods on networks. The many topics covered in this lecture series include lattice Boltzmann schemes, particulate dissipative approaches, particle hydrodynamics, direct Monte Carlo methods, *etc*.

The Scientific Committee of the International Conference DSFD proposed that Paris welcomes its 23$^{\text{th}}$ edition in 2014. This choice stemmed from the international reputation of the city of Paris both scientifically and culturally. In addition, the discrete kinetic approach to fluid mechanics was born in the years 1970-1990 between the mechanics lab at the Université Pierre et Marie Curie (Paris 6 University) and the physics lab of the École Normale Supérieure in Paris. The lattice Boltzmann approach also uses theoretical tools inspired by the Boltzmann kinetic framework, which is a theme of excellence of the French school of mathematics.

Given the various physical areas covered by numerical methods exposed during DSFD conferences, one of the objectives of the 2014 edition, which took place at the École Normale Supérieure in Paris from 28 July to 1 August 2014, was to promote a multi-disciplinary approach by hosting conferences and lectures on highly theoretical subjects, such as those aimed at justifying the Boltzmann lattice algorithms, as well as on very applied topics and even industrial ones. At the fundamental level, conference-goers noted the lattice Boltzmann models of high order, multi-speed models, boundary conditions, *etc*. Among the numerous applications which may be mentioned are optimization of the aerodynamic shape of a car, the problems of multiphase flow for the oil industry, colloidal suspensions, simulation of micro-fluidic devices, *etc*.

Lattice Boltzmann methods (LBM) have developed in recent decades in all countries of the world. It is sufficient to be convinced to read the list of the 13 members of the International Scientific Committee of the conference DSFD 2014: Ilya Karlin (Chairman, Eidgenössische Technische Hochschule Zürich, Switzerland), Santosh Ansumali (Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India), Bruce Boghosian (Boston, USA and American University of Armenia, Yerevan), Jean-Pierre Boon (Université Libre of Brussels), Bastien Chopard (University of Geneva, Switzerland),

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Paul Dellar (University of Oxford, United Kingdom), Jens Harting (Technical University, Eindhoven, Netherlands), Takaji Inamuro (Kyoto University, Japan), Paulo Cesar Philippi (Federal University of Santa Catarina, Brazil), Marisol Ripoll (Forschungszentrum Jülich, Germany), Shan Xiaowen (Beijing Aero-Science & Technology Research Institute, China), Sauro Succi (National Research Council (CNR), Italy) and Alexander Wagner (North Dakota State University, USA).

During the DSFD 2014 conference, we counted 155 participants, including 60 students or postdocs, with more than 30 nationalities from 5 continents. The conference was structured in 24 sessions, some specialized on granular materials, rarefied gases, particles in the flow, compressible flow, turbulence, rheology, porous media, biophysics, and one of them entirely dedicated to industrial applications, particularly in industrial simulation software from the LaBS project (Lattice Boltzmann Solver).

The local organizing committee DSFD 2014 composed of Stéphane Dellacherie (CEA, centre de Saclay, France and École Polytechnique de Montréal, Canada), François Dubois (CNAM Paris and Université Paris-Sud, France), Stéphan Fauve (École Normale Supérieure, Paris, France), Renée Gatignol (Université Pierre et Marie Curie, Paris, France) and Dominique d'Humières (CNRS and École Normale Supérieure, Paris, France) was responsible for contacts with the journal ESAIM:ProcS.

This issue entitled *Lattice Boltzmann methods and numerical analysis* brings together six selected contributions proposed by the Local Organizing Committee and validated by the International Scientific Committee. Each contribution has led to a review process by at least two referees. Let us underline that other contributions were published in the Journal of Statistical Physics (*Lattice Boltzmann Algorithms and Statistical Physics*, J. Stat. Phys., 161(6), 2015), in Comptes Rendus de l'Académie des Sciences – Mécanique (*Lattice Boltzmann methods for solving problems in mechanics / Méthodes de Boltzmann sur réseau pour la résolution de problèmes de mécanique*, CRAS, Series IIB, Mechanics, 343(10-11), 2015) and in Mechanics & Industry (*Discrete Simulation of Fluid Dynamics*, 17(2), 2016).

This special issue of ESAIM:ProcS includes five articles where the lattice Boltzmann method is analyzed from the numerical analysis point of view and is used to perform numerical simulations of fluid flows in classical, relastivistic and quantum frameworks. The sixth and last article does not concerned the lattice Boltzmann method, the DSFD conference being opened to other numerical methods.

The three first articles concern lattice Boltzmann methods used to discretize the incompressible Navier-Stokes equations. The first article studies a new lattice Boltzmann method which improves the accuracy and stability, and which allows to simulate incompressible flows with high Reynolds numbers. This lattice Boltzmann method uses a notion of entropy to obtain these properties. The second article studies the accuracy of solid wall boundary conditions by using Taylor expansions. The third article proposes boundary conditions allowing to minimize spurious reflecting waves in a bounded domain.

The fourth article applies the lattice Boltzmann method in a relativistic framework. The authors study in particular a cooling effect induced by a Richtmyer-Meshkov instability in the relativistic context.

The fifth article applies the lattice Boltzmann method to solve a Schrödinger equation and shows connections with finite difference type schemes.

The sixth article is not at all related to the lattice Boltzmann methods realm. It concerns the behaviour of Godunov type schemes in the low Mach number regime.

We hope that with this special issue, we have introduced some of the numerical analysis questions opened by the lattice Boltzmann methods and that we have demonstrated the wide variety of physical problems that these methods allow us to study. Let us add that these simulation methods, because of their ease of implementation and adaptation to numerous physical problems, represent a huge potential both from the point of view of basic research as well as industrial applications.

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