

The Lattice Boltzmann Equation for Fluid Dynamics and Beyond

by Sauro Succi (Clarendon Press, Oxford, 2001) ISBN 0 19 850398 9

Suppose point particles move along the links of a regular lattice hopping from node to node at regular time intervals and undergo collisions when they encounter at a node. Streaming and collisions of particles is just what the Boltzmann equation describes in mathematical terms. But here since the particles reside on a lattice and move at the tick of a clock, space-time is discretized (and so is phase space), and the equation that gives the mesoscopic description of this fictitious fluid – called the lattice gas automaton (LGA) – is the *lattice* Boltzmann equation (LBE). Classical statistical mechanics tells us how to go from the Boltzmann equation to the macroscopic equations of fluid dynamics. The “little miracle” is that, despite the oversimplification of the underlying model, the lattice Boltzmann fluid can also be shown to obey the Navier–Stokes equations, and so provides a new approach to simulate hydrodynamics. Because it is so simple, we may have gained something in terms of theoretical understanding, and because the LBE is easy to implement, we may also have gained something in terms of computational capabilities.

This is what the book under review is about and as such it is a most welcome volume in the area of fluid dynamical theory and applications. As a matter of fact, to my knowledge, this is the first monograph entirely devoted to the lattice Boltzmann approach to fluid dynamics, a method which has proved not only very useful, but also quite promising, so justifying the “beyond” in the title. Sauro Succi has been one of the pioneers in the development of the subject which he masters from the theoretical point of view as well as for numerical simulations and applications. Both aspects are developed in detail in the book which reflects Succi’s expertise: he is at home with the subject and his particular fluent style shows it. The book reads indeed quite well as it takes the reader smoothly through the scenario of how the lattice Boltzmann method emerged from the lattice gas approach and led to the lattice version of the Batnaghar, Gross, Krook model (LBGK), then helps the reader through the meanders of a variety of classical applications and of new problems in the field of fluid dynamics, and eventually “beyond”.

The book starts with introductory chapters on kinetic theory and lattice gas automata. These topics are presented in an intuitive fashion, emphasizing ideas rather than mathematical formalism. But the essentials are there. To quote the author, the “book relies more on physical intuition and heuristic arguments than on detailed mathematical analysis”. Nonetheless, when one arrives at the core of the subject – the lattice Boltzmann equation – things get more technical and detailed as they should.

There are several nice features that make the book attractive: the slanted intro’s to each chapter pin-pointing ideas and concepts developed in the forthcoming chapter, the author’s personal views, the discussions paralleling LBE and CFD methods, the connection with quantum systems, the field theoretical analogies, . . . The overall structure of the book is logical and solid, and the theory follows the path of simplicity to complexity then back to simplicity (with LBGK). There is a large spectrum of applications: some merely convey messages and suggestions for interesting or new problems, but most applications are developed in detail. The researcher will find the technical aspects very useful, while the beginner will first make its way through by carefully working out the exercises. Then the question arises as to when and where does the LBE method offer real advantages versus other numerical techniques. Succi gives a quite sensible answer in his closing chapter entitled ‘Who needs LBE?’ where he classifies applications into four groups: DU (don’t use), CU (can use), SU (should use), MU (must use), and guides the reader away from dead ends and towards safe and potentially interesting routes.

In conclusion, Succi’s book should be recommended as a most valuable contribution to the literature of fluid dynamics, and as a very useful complement to recent books on discrete models and lattice gas automata.

Jean Pierre Boon

*Faculté des Sciences**Université Libre de Bruxelles**Campus de la Plaine’ CP 231**Bruxelles 1050**Belgium**E-mail address: jpboon@ulb.ac.be (J.P. Boon)*