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Large Scale Lattice-Boltzmann Simulations: Computational Methods and Applications

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Publication date
1999

[Link to publication](#)

Citation for published version (APA):

Kandhai, B. D. (1999). *Large Scale Lattice-Boltzmann Simulations: Computational Methods and Applications*. Universiteit van Amsterdam.

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Chapter 1

Computer simulations in fluid dynamics

Part I

1.1 Fluid dynamics

Introduction

A wide variety of applications have been found for the natural sciences and engineering are strongly dependent on the knowledge of fluid mechanics. Typical examples are the atmosphere and the oceans, the flow of blood through complex capillary vessels, around water pollution, compressible flow around an airfoil, and numerous other interesting problems which are of great relevance for the industrial and academic community [1, 2, 3, 4, 5]. A good understanding of the dynamics of fluids is therefore extremely useful in improving several industrial processes and designs, e.g. the wing of an airplane, and may contribute significantly to our knowledge of many fundamental scientific problems, e.g. the impact of hydrodynamics on the morphology of biological growth forms [6].

Although the basic equations for these flows are known of fluids, the so-called Navier-Stokes equations, were first derived in 1829 [3]. The general solution to this problem is, due to its non-linearity, still unknown. The general complex flow patterns that may arise are widely investigated. Moreover, a modern approach is hampered by the fact that the equations are not well-posed [1, 2]. Fluid mechanics is therefore commonly studied by either (i) researchers from their own perspectives and with a well-defined motivation, e.g. compressible flow around an airfoil, the Navier-Stokes equations [7], or (ii) by a study of the history of fluid dynamics, showing that the following properties are constantly met, in studying these phenomena:

1.1.1 The fluid mechanics

The main objective of this book is to show that experimental observations of the flow of fluids are complex, as well known, and that the Navier-Stokes equations

