Computational Fluid Dynamics

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EDITORS

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COMPUTATIONAL FLUID DYNAMICS

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PREFACE

This volume contains most of the papers presented at the International Symposium on Computational Fluid Dynamics, which took place in August 1987 in Sydney, Australia. The Symposium was held concurrrently with the International Conference on Computational Techniques and Applications (CTAC-87), the Proceedings of which are published by North-Holland in a separate volume.

The Symposium and the Conference were designed to bring together engineers, scientists, numerical analysts and mathematicians interested in the development of efficient computational techniques and in their application to fluid flow problems of engineering and scientific importance.

Invited and contributed papers were presented in the following general research areas:

> Boundary Layer Flow; Combustion and Chemically Reacting Flows; Free Surface Flows; Geophysical Flows; Inviscid Flow; Meteorological Flows; Non-Newtonian Flow; Numerical Methods and Analysis; Porous Media; Separated Flow; Shallow Water Problems; Shock Wave Interactions; Stability and Transition; Supercomputers; Supersonic and Transonic Flow; Thermal Convection; Turbulent Flows and Modelling; Viscous Flow; Vortex Flow.

Because some papers covered more than one of these areas, they have been organised in this volume in alphabetical order of first author, with the invited papers preceding the contributed papers. Several papers will be published in an expanded form in a special issue of International Journal for Numerical Methods in Fluids; and the full text of one paper was not received. Only the abstracts of these papers are presented here.

The Editors would like to acknowledge the assistance of their fellow Organising Committee members: Dr. J.D. Atkinson (Secretary; Univ. of Syd.), Professor G.A. Bird (Univ. of Syd.), Assoc. Prof. G.P. Steven (Univ. of Syd.), Dr. D.W. Kelly (Univ. of NSW), Dr. R. Womersley (Univ. of NSW), Dr. R.S. Anderssen (CSIRO Canberra), Dr. F.R. de Hoog (CSIRO Canberra) and Dr. R. Kohoutek (Univ. of Wollongong).

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Graham de Vahl Davis
Clive Fletcher

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INVITED PAPERS

Computational Fluid Dynamics
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HYDRODYNAMICS OF LATTICE GASES.

by Henri Cabannes

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Abstract. We explain the principle of the method called, "The Method of Lattice Gases". This method allows the simulation of fluid motions by considering particles moving between one vertex and another in either a regular plane, or three dimensional, network; these networks can contain several million vertices. The motions obtained from this method are compared to the motions modelled by the classical macroscopic equations, and also to the known real motions. At the end we explain the perspectives that have been opened by this new method.

Contents

1°) Introduction. The method of lattice gases is a new numerical method used to study the motion of fluids. The classical methods express the physical laws (satisfied by a fluid in motion), in the form of partial differential equations; these are then solved numerically by different methods of discretisation. The method of lattice gases is also a method of dicretisation, but in this method instead of discretizing the equations, one discretise directly the medium.

The idea, to represent a fluid not by a continous medium but by a discrete distribution of matter, is very old. It gave birth, in the last century, to the kinetic theory of gases; the foundations of this theory has been established by Maxwell and by Boltzmann, who derived in 1872 the equation of Boltzmann. Boltzmann equation is a fundamental equation in rarefied gas dynamics. The kinetic theory of gases (in which the object of which is to deduce macroscopic properties from an initially microscopic study) made rapid progress about twenty years ago. This was because of importance of flight in the rarefied atmosphere (due to the launching of artificial satellites), and also because of the advent of computers, which greatly increwed the performance numerical experiments.

In the original kinetic theory, the fluid is a discrete system, but each molecule occupies a position and has a velocity, which varies continuously with time. In 1964, an American, Broadwell, in view of a numerical treatment, had the idea to study a gas, the molecules of which can have only six velocities (these velocities were of the same magnitude, and along orthogonal axes). A few years later, in Paris Mme R. Gatignol has achevied a complete study of the kinetic theory of gases with a discrete distribution of velocities, first in her thesis in 1973, then in her book in 1975. In a calculation by computer, using the kinetic theory of gases with discrete velocities, it is convenient to use regular models, that is models with some symmetries. As we are living in a three dimensional space, the number of these models is very limited; they are related to the existence of convex regular polyhedrons; there exists only five such polyhedrons.

In the discrete velocities kinetic theory, the matter is discretized, the space velocities are discretized, but the physical space is continuous. It is possible to continue the discretisation, by discretising also the physical space; this continuation is at the origin of the theory of lattice gases. For those gases, the number of models is also very small, since the construction of planes with regular polygons is possible in only three different manners: with hexagons, squares and triangles; in the three dimensonal space it exists in only one regular lattice: the cubic lattice. This last difficulty can by avoided by a transition to four dimensional space velocities, and by considering then the motions which depend (in the physical space) on only three space variables.