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Preface to the Series in Information and Computational Science

Since the 1970s, Science Press has published more than thirty volumes in its series Monographs in Computational Methods. This series was established and led by the late academician, Feng Kang, the founding director of the Computing Center of the Chinese Academy of Sciences. The monograph series has provided timely information of the frontier directions and latest research results in computational mathematics. It has had great impact on young scientists and the entire research community, and has played a very important role in the development of computational mathematics in China.

To cope with these new scientific developments, the Ministry of Education of the People's Republic of China in 1998 combined several subjects, such as computational mathematics, numerical algorithms, information science, and operations research and optimal control, into a new discipline called Information and Computational Science. As a result, Science Press also reorganized the editorial board of the monograph series and changed its name to Series in Information and Computational Science. The first editorial board meeting was held in Beijing in September 2004, and it discussed the new objectives, and the directions and contents of the new monograph series.

The aim of the new series is to present the state of the art in Information and Computational Science to senior undergraduate and graduate students, as well as to scientists working in these fields. Hence, the series will provide concrete and systematic expositions of the advances in information and computational science, encompassing also related interdisciplinary developments.

I would like to thank the previous editorial board members and assistants, and all the mathematicians who have contributed significantly to the monograph series on Computational Methods. As a result of their contributions the monograph series achieved an outstanding reputation in the community. I sincerely wish that we will extend this support to the new Series in Information and Computational Science, so that the new series can equally enhance the scientific development in information and computational science in this century.

Shi Zhongci
2005.7

Preface

Computational fluid dynamics (CFD) uses large scale numerical computation to solve problems of fluid flow. It has been known since its onset that the numerical solution to a given flow depends on the relation between the flow and the coordinates (mesh) used to compute it. Each of the two well-known coordinate systems for describing fluid flow—Eulerian and Lagrangian—has advantages as well as drawbacks. Eulerian method is relatively simple, but its drawbacks are: ① it smears contact discontinuities badly; ② it needs generating a body-fitted mesh prior to computing flow past a body. Lagrangian method, by contrast, resolves contact discontinuities (including material interfaces and free surfaces) sharply, but it also has drawbacks: ① the gas dynamics equations could not be written in conservation partial differential equations (PDE) form, rendering numerical computation complicated; ② it breaks down due to cell deformation.

A fundamental issue in CFD is, therefore, the role of coordinates and, in particular, the search for "optimal" coordinates. It is in the long search for an optimal coordinate system that a unified coordinate (UC) system was developed by the first author and his collaborators over the last decade. While the search for an optimal coordinate system in CFD would undoubtedly continue, the unified coordinate system developed so far is found to combine the advantages of both Eulerian and Lagrangian system, while avoiding their drawbacks. Indeed, it goes beyond these. For instance, the UC system provides a foundation for automatic mesh generation by the flow being computed.

This monograph first reviews the relative advantages and drawbacks of Eulerian and Lagrangian coordinates as well as the Arbitrary-Lagrangian-Eulerian (ALE) and various moving mesh methods in CFD for one- and multi-dimensional flow. It then systematically introduces the unified coordinate approach to CFD, illustrated with numerous examples and comparisons to clarify its relation with existing approaches.

The content of this monograph is based on a graduate course taught by the first

author from 2000 to 2007 at the Hong Kong University of Science and Technology, Academia Sinica in Taiwan, Hong Kong Polytechnic University and Hong Kong Baptist University, and by the second author since 2009. We thank Prof. T. Tang for his comments on the first draft of the book. We also acknowledge the permission of Communication in Computational Physics (CiCP) for allowing us to use the material presented in a review paper[①].

Many scientists have made substantial contributions in the course of development of the UC approach to CFD. Here is a partial list: Chien-Cheng Chang, De-Lin Chu, Bo Gao, Yuan-Ping He, Jeu-Jiun Hu, Changqiu Jin, Sergei Kudriakov, Chih-Yu Kuo, Claude Lepage, Zuo-Wu Li, Ping-Yiu Li, Meng-Sing Liou, Ching Yuen Loh, Yang-Yao Niu, Keh-Ming Shyue, Ronald Ming Cho So, Yih-Chin Tai, Henry Van Roessel, Zi-Niu Wu, Jaw-Yen Yang, Gui-Ping Zhao, Yanchun Zhao. Without their valuable contributions, the UC approach to CFD could not have reached its current state of maturity. We also thank our secretary Odissa Wong for her help for many years in editing and preparing the figures. We give special thanks to our wives, Kwok Lan Hui and Jie Shen, for their strong support to us in writing this monograph.

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Wai-How Hui
Kun Xu
Hong Kong University of Science and Technology
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① The unified coordinate system in computational fluid dynamics. *Communications in Computational Physics*, 2: 577-610, 2007.