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Theoretical considerations of Boltzmann-equation based CFD methods for continuum flows

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Abstract:

Boltzmann-equation based methods such as the lattice Boltzmann method and the discrete unified gas kinetic scheme now play a major role in computational fluid dynamics, due to their simplicity in formulation, feasibility in incorporating microscopic physics, low numerical dissipation, and advantages in parallel implementation. In most cases, they are used to simulate continuum flows, namely, as an alternative approach for solving the Navier-Stokes-Fourier system or multiphase flow systems. In this sense, Boltzmann-equation based methods are methods deigned in a high-dimensional configuration space, which bear both advantages and drawbacks. The design of the model Boltzmann equations for the interior nodes, the implementation of hydrodynamic boundary conditions at the boundary nodes, and the proper and efficient initialization in the case of turbulent flow simulation are the major considerations that determine their capabilities, accuracy, computational efficiency and numerical stability. The design details are not unique, and merits and issues in these should be carefully analyzed. In this talk, I shall discuss and illustrate these aspects and our recent progress from theoretical viewpoints, together with various simulation results.

Brief Bio:

Dr. Lian-Ping Wang received a Batchelor's degree in Mechanics from Zhejiang University, Hangzhou, China in 1984, and a PhD in Mechanical Engineering from Washington State University in 1990. He was then a Visiting Research Associate at Brown University from 1990 to 1992, after which he was a Research Associate at Pennsylvania State University from 1992 to 1994 and an Assistant Professor of Mechanical Engineering at the University of Delaware from

1994 to 2001. He became an Associate Professor in 2001 and a Professor in 2010 at the University of Delaware. In 2017, he was appointed a Chaired Professor at Southern University of Science and Technology, China. Dr. Wang's areas of expertise include computational fluid dynamics, turbulence, particle-laden flow and immiscible multiphase flow, and their applications to industrial and atmospheric processes. In recent years, he has focused on the mesoscopic CFD method based on Boltzmann equation and its application in direct numerical simulation of complex flows. He has published close to 200 refereed journal papers and has given over 100 invited talks. Dr. Wang became an elected Fellow of American Physical Society in 2011 and an elected Fellow of American Society of Mechanical Engineers in 2016. He became an Associate Editor of Journal of Fluid Mechanics in May 2022.