9th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMA2024)
June 3-7, 2024, Lisbon, Portugal

KINETIC-BASED COMPUTATIONAL FLUID DYNAMICS FOR CONTINUUIM AND RARIFIED FLOWS

TRACK NUMBER 800

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Keywords: kinetic-based computational fluid dynamics, lattice Boltzmann method, gas kinetic scheme, GPU parallel computing.

ABSTRACT

Computational Fluid Dynamics (CFD) has been a powerful tool for the comprehension of complex fluid dynamics. However, traditional CFD methods, grounded in continuum assumptions, may falter in scenarios with increased Knudsen numbers, e.g., rarefied gas dynamics and microfluidics. Kinetic-Based Computational Fluid Dynamics (KCFD) offers a more proper approach, transcending the conventional continuum regime. Instead of relying on the Navier-Stokes equations, KCFD employs the Boltzmann equation from kinetic theory to compute fluid dynamics from the moments of fluid particle distribution functions. Operating at the mesoscopic level, KCFD forms a fundamental framework adaptable to a broad spectrum of Knudsen numbers, spanning from continuous hydrodynamics to rarefied gas dynamics. Rooted in the Boltzmann equation, KCFD naturally models various phenomena, such as interfacial dynamics in multiphase flows, non-Newtonian effects, fluid-structure interaction, rarefication, magnetohydrodynamics (MHD), and more. Two well-established KCFD methodologies are the lattice Boltzmann method (LBM) and the gas kinetic scheme (GKS). Notably, both exhibit compelling advantages, including suitability for GPU parallelization, ease of programming, and direct integration of physical effects into the modeling process. We aim to bring together researchers and practitioners from diverse fields in this minisymposium (MS) to explore the capabilities and applications of KCFD in tackling complex flows. The primary objective is to provide a platform for interdisciplinary discussions, knowledge exchange, and the dissemination of recent developments in KCFD. We aim to (1) showcase the latest advancements in KCFD methodologies, algorithms, and applications, (2) foster collaboration and networking opportunities among researchers working on KCFD from various disciplines, and (3) discuss challenges and opportunities in implementing KCFD in real-world applications. We invite abstracts that encompass a wide range of topics related to KCFD, including but not limited to methodologies and algorithms, validation and verification, uncertainty quantification, applications, GPU parallel computing, interdisciplinary research, and future directions. This MS will serve as a vibrant forum for researchers to explore the cutting-edge developments and applications of KCFD. We invite participants to join us in advancing our understanding of complex fluid dynamics through the lens of kinetic-based simulations.