Unified CFD Framework for Nearly Incompressible to Supersonic Flows on Supercomputers: Challenges and Applications

ChungGang Li[1,2]

[1] Department of Mechanical Engineering, National Cheng Kung University
[2] Division of Computational Aerodynamics and Combustion, Taiwan Space Agency

Solving compressible flow across all speed regimes is one of the most challenging tasks in CFD due to the varying scales between sound speed and flow speed. To address this challenge and maximize practical applications, this talk will introduce a unified CFD framework developed by the speaker over the past 20 years. This framework encompasses an all-speed compressible flow solver, turbulence models, the immersed boundary method, wall models, and time-stepping schemes to accommodate diverse applications. All numerical schemes are implemented using a hierarchical structured grid known as the Building Cube Method (BCM) to leverage the computational power of supercomputers. The framework's capabilities will be demonstrated through several important practical applications requiring all-speed compressible solvers, including vehicle aeroacoustics, COVID-19 infection risk evaluation, and supersonic converging-diverging (CD) nozzles, among others.

Keywords: Compressible flow, All speed regimes, CFD, Supercomputers