6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Consistent High Resolution Interface-Capturing Finite Volume Scheme for Compressible Multi-Material Flows

Qiuju Wang[1], Ralf Deiterding[2]

[1] Institute of Applied Physics and Computational Mathematics, Beijing, 100094, China.
Qiuju.Wang@soton.ac.uk
[2] Aerodynamics and Flight Mechanics Research Group, University of Southampton,
Highfield Campus, Southampton SO171BJ, United Kingdom.
R.Deiterding @soton.ac.uk

Key Words: *High Resolution, Interface Capturing, Compressible Multi-Material Flows.*

Compressible multi-material flows are characterized by complex flow structures and discontinuities associated with material interfaces and shock waves. Finite volume method is naturally conservative for equations of fluid dynamics and particularly suitable for problems with shocks and other flow discontinuities including material interfaces. High resolution finite volume scheme is proposed to simulate compressible multi-material flows which can robustly capture the material interfaces and shocks. Low dispersion and dissipation schemes are crucial for simulations of flow fields with a broad range of length scales, especially for multi-material interface instabilities and turbulent mixing. The dispersion and dissipation properties are proved to be independent [1] and then can be optimized through spectral analysis to achieve high resolution finite volume scheme. The minimized dispersion and controllable dissipation (MDCD) finite volume scheme by Wang et al. [2], in which the dispersion and dissipation errors are optimized separately, has shown desirable spectral properties.

The consistent MDCD finite volume scheme is implemented for simulations of compressible multi-material flows, which can capture flow discontinuities, maintain the velocity, pressure and temperature equilibriums and then suppress spurious oscillations near material interfaces. The present consistent high resolution finite volume scheme solves a fully conservative form of the total mass, momentum, total energy and species-mass and additional advection form of parameters in equation of state of fluid mixture, for perfect gas which is specific heats ratio, to prevent pressure oscillations and temperature spikes. A fourth-order MDCD spatial reconstruction with optimized spectral properties and a Harten-Lax-van Leer contact (HLLC) approximate Riemann solver are utilized to compute the convective fluxes. A third-order total variation diminishing (TVD) Runge-Kutta (RK) algorithm is employed to march the solution in time. The properties of the presented scheme are verified by several one- and two dimensional multi-material test cases.

REFERENCES

[1] Zhen-Sheng Sun, Yu-Xin Ren, Cledric Larricq, Shi-ying Zhang,Yue-cheng Yang. A class of finite difference schemes with low dispersion and controllable dissipation for DNS of compressible turbulence. J. Comput. Phys., 230:4616-4635, 2011.

[2] Qiuju Wang, Yuxin Ren, Zhensheng Sun, Yutao Sun. Low dispersion finite volume scheme based on reconstruction with minimized dispersion and controllable dissipation. Science China: Physics, Mechanics & Astronomy, 56(2): 423-431, 2013.