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Hybrid LBM for Transonic Propulsion Flows

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A hybrid Lattice-Boltzmann/Finite-Volume (LBM/FV) solver is developed to extend the applicability of LBM to transonic internal flow configurations often found in propulsion systems. A D3Q19 Hybrid Recursive Regularized (HRR) LB [1], is used to solve the mass and momentum conservation equations. The total energy equation is solved using a finite-volume (FV) solver. This methodology has been previously validated on a High-Pressure turbine cascade [2], resulting in an accurate prediction of the flow dynamics around the cascade. However, the conservativity of the method was not taken into account. In the present work, particular effort is put in establishing a mass and energy conserving boundary treatment by directly incorporating the LB mass flux into the FV energy flux. The aim is to recover conservative and smooth near wall density and pressure fields, respectively, despite the non-conforming cartesian grid used in LBM near curved solid boundaries.
The present method is validated on the internal flow of the Sajben transonic converging-diverging diffuser. The flow configuration follows the experimental set-up of [3, 4], which involves a weak shock in the diverging part of the channel, as shown in Figure 1. The ability of the method to accurately predict the pressure evolution along the top and bottom walls as well as the shock position is assessed by comparing to experimental data. The mass conservation is also examined by measuring the flow rate at different sections of the diffuser.

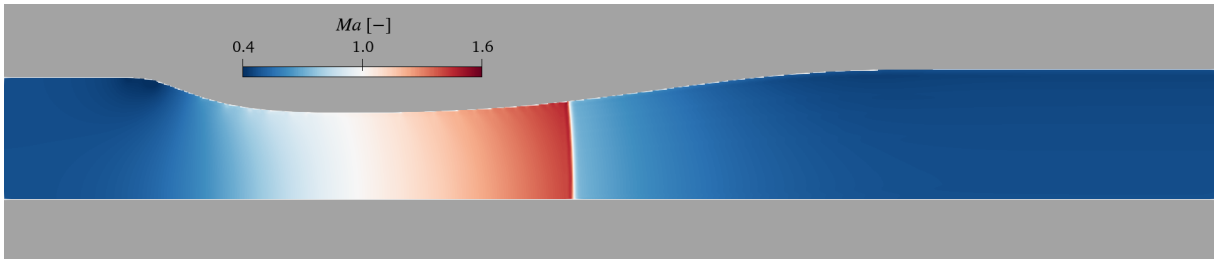

Figure 1: Mean Mach field Ma in the Sajben transonic diffuser.

References

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