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Transitional shock-wave/boundary-layer interactions with side-wall effects

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Three-dimensional transitional shock-wave/boundary-layer interactions with side-wall effects were simulated in the Python based code-generation framework OpenSBLI [1], for a Mach 1.5 inflow and shock-generator wedge angle of 2.5°. Shock-capturing was performed by a 7th order Weighted Essentially non-Oscillatory (WENO) scheme, using the WENO-Z formulation outlined in [2]. Viscous derivatives were computed with 4th order central differencing, replaced by a 4th order one-sided derivative at the boundaries. A 3rd order low-storage strong stability preserving (SSP) Runge-Kutta scheme was used for time-advancement. All simulations were performed on multi-GPU configurations of NVIDIA P100 GPUs with CUDA+MPI.

The computational domain was initialized with a similarity solution laminar boundary-layer, at free-stream temperature of $202.17K$. No-slip isothermal wall conditions were enforced on the bottom and sides of the domain, with extrapolation boundary conditions applied at the inlet and outlet. An incident shock-wave was generated with a no-slip isothermal wedge inclined at 2.5°, causing regions of separated flow on the lower and side surfaces. To trigger a transition to turbulence, a strip of time-dependent modal forcing was added to the bottom no-slip wall. Modes provided by linear stability theory of a separation bubble by [3] were used, with the most unstable mode selected for this work. The effect of the transition is to cause a sharp increase in skin-friction downstream of the main separation bubble. A reduction in separation bubble length is also observed for the transitional case, proportional to the amplitude of the applied forcing.

REFERENCES

[1] Christian T. Jacobs, Satya P. Jammy, and Neil D. Sandham. OpenSBLI: A framework for the automated derivation and parallel execution of finite difference solvers on a range of computer architectures. *Journal of Computational Science*, 18:12 – 23, 2017.

[2] Rafael Borges, Monique Carmona, Bruno Costa, and Wai Sun Don. An improved weighted essentially non-oscillatory scheme for hyperbolic conservation laws. *Journal of Computational Physics*, 227(6):3191–3211, 2008.

[3] Andrea Sansica. *Stability and unsteadiness of transitional shock-wave/boundary-layer interactions in supersonic flows.* PhD thesis, University of Southampton, 2015.