High-Fidelity CFD Workshop 2021
Shu-Osher shock-entropy wave interaction

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1 Summary

The Shu-Osher problem is a one-dimensional idealization of shock-turbulence interaction in which a shock propagates into a density field with artificial fluctuations. The goal of this problem is to test the capability to accurately capture a shock wave, its interaction with an unsteady density field, and the waves propagating downstream of the shock. The accuracy of numerical solutions will be measured by the $L^2(\Omega)$ error at the final time T with respect to a reference solution computed on a fine mesh and the space-time geometry of the shock.

2 Governing equations and flow conditions

The governing equations are the 1D compressible Euler equations for an ideal gas with a constant ratio of specific heats equal to $\gamma = 1.4$. The flow domain is $\Omega = (-5, 5)$ and the time domain is $(0, T)$ with $T = 2$. The initial condition for the flow is

$$(\rho, u, p) = \begin{cases} (3.857143, 2.629369, 10.3333) & x < -4 \\ (1 + 0.2\sin(5x), 0, 1) & x \geq -4 \end{cases}$$

with a supersonic inlet at $x = -5$ that prescribes the density, velocity, and pressure

$$(\rho, u, p) = (3.857143, 2.629369, 10.3333)$$

and a solid wall at $x = 5$. This problem corresponds to a Mach $M = 3$ shock moving into a field with a small density (or entropy) disturbance.

3 Mandatory campaign

Perform the simulation of the Osher-Shu problem over the indicated time interval. Report the position of the shock (x_s) at the final time T and the L^2 error of the density field (E_ρ) at the final time with respect to the provided reference solution on a sequence of successively refined meshes and time steps. The reference solution is provided on the website along with Python scripts to compute E_ρ given pointwise evaluations of the solution. In addition, report the number of degrees of freedom (spatial and temporal), the number of cells, and a succinct description of the method/mesh/elements/solver used, e.g., DG, Roe-flux, isoparametric, RK4, etc.

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4 Optional campaign

1. Report the work units required to obtain the solution at the final time of each of the discretizations considered according to the workshop guidelines[1].

2. Report the shock geometry in space-time for each discretization. The shock geometry can be specified as a piecewise linear curve consisting of a list of point coordinates. Alternatively, if a higher order representation is used, provide a standalone script that can be used to sample the coordinates of the curve as a function of a parameter $s \in (0, 1)$.

5 Contact

For questions regarding the problem setup or reporting requirements, contact Matthew J. Zahr (mzahr@nd.edu).

[1] https://how5.cenaero.be/content/guidelines