Shock Tube

Problem Description

The shock tube problem is a standard 1D compressible flow problem that has been used by many as a validation test case [1, 2, 3]. At time $t = 0$ the computational domain is divided into two separate regions of space by a diaphram, with each region at a different density and pressure. The separated regions are at rest with a uniform temperature $= 300K$. The initial pressure ratio is $\frac{P_R}{P_L} = 10$ and density ratio is $\frac{\rho_R}{\rho_L} = 0.1$ The diaphram is instantly removed and a traveling shockwave, discontinutity and expansion fan form. The expansion fan moves towards the left while the shockwave and contact discontinutity move to the right. This problem tests the algorithm's ability to capture steep gradients and solve Eulers equations.

Simulation Specifics

Component used: ICE

Input file name: shocktube.ups

Command used to run input file: sus shocktube.ups

Postprocessing command:
inputs/UintahRelease/ICE/plot_shockTube_1L shockTube.uda

Simulation Domain: 1 x .01 x .01 m

Cell Spacing:
0.1 x 10 x 10 mm (Level 0)

Example Runtimes:
2 minutes (1 processor, 2.4 GHz Xeon)

Physical time simulated: 0.005 sec.

Results

Figure 2 shows a comparison of the exact versus simulated results at time $t = 5msec$.

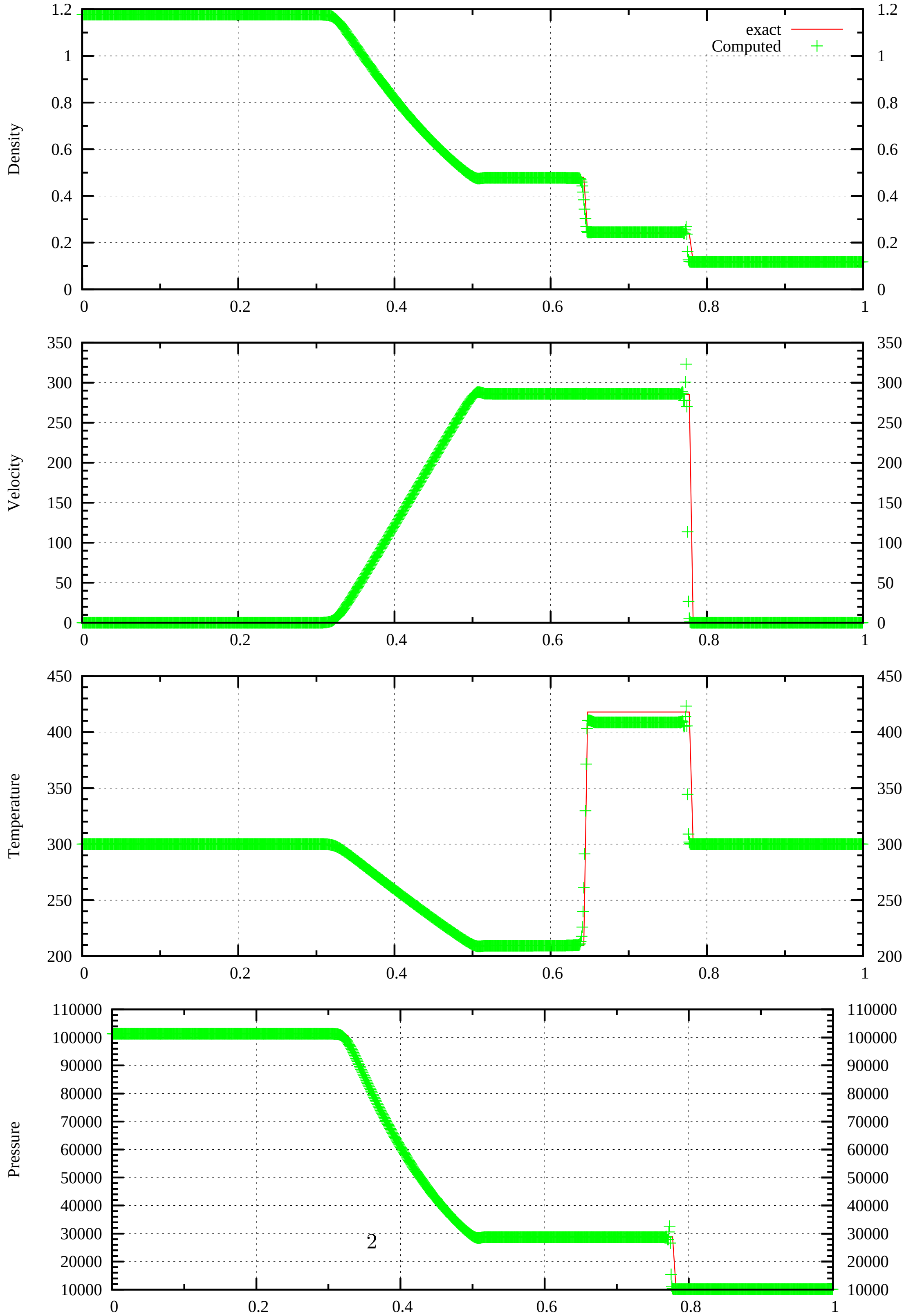

Figure 1: Shock tube results at time $t = 5msec$

Shock Tube with AMR

Simulation Specifics

Component used: ICE

Input file name: shocktube_AMR.ups

Command used to run input file: sus shocktube_AMR.ups

Postprocessing command:
inputs/UintahRelease/ICE/plot_shockTube_AMR shockTube_AMR.uda

Simulation Domain: 1 x .01 x .01 m

Cell Spacing:
0.1 x 10 x 10 mm (Level 0) 0.025 x 10 x10 mm (Level 1) 0.00625 x10 x10 mm (Level 2)

Example Runtimes:
2ish minutes (1 processor, 2.4 GHz Xeon)

Physical time simulated: 0.005 sec.

Results

Figure 2 shows a comparison of the exact versus simulated results at time $t = 5msec$.

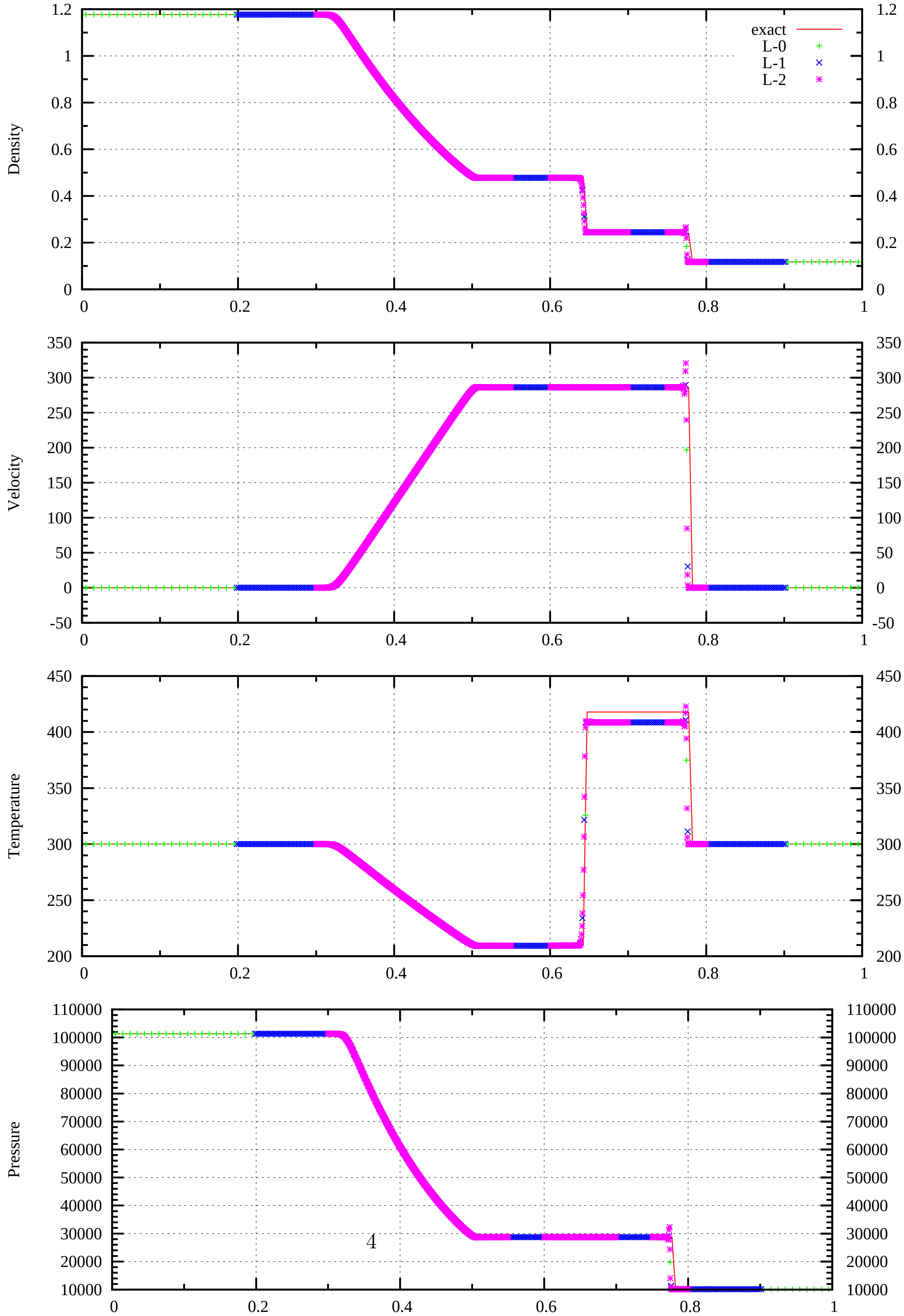

Figure 2: Shock tube results at time $t = 5msec$

References

[1] C. B. Laney. *Computational Gasdynamics*. Cambridge University Press, Cambridge, 1998.

[2] G. A. Sod. A survey of several finite difference methods for systems of nonlinear hyperbolic conservation laws. *J. Comput. Phys*, 27:1–31, 1978.

[3] E. F. Toro. *Riemann Solvers and Numerical Methods for Fluid Dynamics A Practical Introduction*. Springer, Berlin, second edition, 1999.