C1.1 Internal inviscid flow over a smooth bump

1. Code description

XFlow is a high-order discontinuous Galerkin (DG) finite element solver written in ANSI C, intended to be run on Linux-type platforms. Relevant supported equation sets include compressible Euler, Navier-Stokes, and RANS with the Spalart-Allmaras model. High-order is achieved compactly within elements using various high-order bases on triangles, tetrahedra, quadrilaterals, and hexahedra. Parallel runs are supported using domain partitioning and MPI communication. Visual post-processing is performed with an in-house plotter. Output-based adaptivity is available using discrete adjoints.

2. Case summary

The default implicit Newton solver was used for all runs in this case. The residual was converged to an absolute L_1 norm below 10^{-10} using a conservative state vector of $\mathcal{O}(1)$ freestream density, velocity, and pressure, and gas constant $R = 1.0$. Runs were performed on the *nyx* supercomputing cluster at the University of Michigan. The number of cores ranged from 4 on the coarsest meshes to 40 on the finest meshes. On one core of the nyx machine, one TauBench unit is equivalent to 16.5 seconds of compute time.

3. Meshes

The meshes were generated using a Matlab script with Q=5 and consisted of triangular elements. Boundary conditions consisted of a subsonic inflow and outflow, a slip wall on the bottom, and a symmetry on the top.

4. Results

The following figures and tables show the requested data for this case.

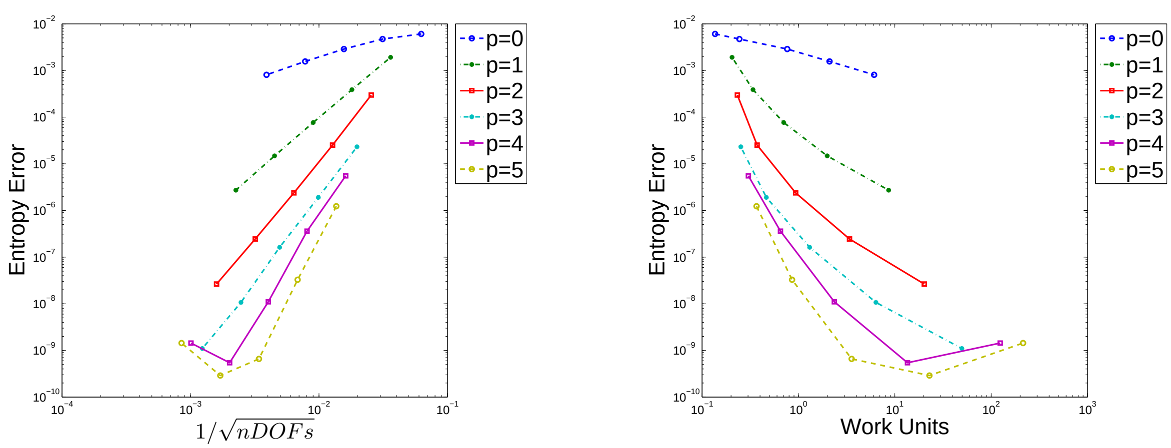

Figure 1: Convergence of entropy error with h refinement and work units.

Table 1: Relevant data for the bump case.

Order	Ref=0	Ref=1	Ref=2	Ref=3	Ref=4
$p = 0$	1.5186e-2	1.1793e-2	7.2093e-3	3.9096e-3	2.0227e-3
Rate	-	0.4	0.7	0.9	1.0
Work	1.3648e-1	2.4436e-1	7.6606e-1	2.1059e+0	6.1021e+0
$p = 1$	4.7841e-3	9.7005e-4	1.9211e-4	3.6900e-5	6.8072e-6
Rate	-	2.3	2.3	2.4	2.4
Work	2.0485e-1	3.3818e-1	7.0400e-1	1.9905e+0	8.6320e+0
$p = 2$	7.4197e-4	6.2777e-5	5.9565e-6	6.1204e-7	6.6326e-8
Rate	-	3.6	3.4	3.3	3.2
Work	2.3248e-1	3.7285e-1	9.3648e-1	3.3896e+0	2.0223e+1
$p = 3$	5.7706e-5	4.7706e-6	4.0722e-7	2.6755e-8	2.7535e-9
Rate	-	3.6	3.6	3.9	3.3
Work	2.5236e-1	4.6497e-1	1.3074e+0	6.3695e+0	4.9712e+1
$p = 4$	1.3804e-5	8.9902e-7	2.7545e-8	1.3611e-9	3.6006e-9
Rate	-	3.9	5.0	4.3	-1.4
Work	3.0255e-1	6.5139e-1	2.3595e+0	1.3538e+1	1.2410e+2
$p = 5$	3.0758e-6	8.1900e-8	1.6444e-9	7.2406e-10	3.6006e-9
Rate	-	5.2	5.6	1.2	-2.3
Work	3.6776e-1	8.5964e-1	3.5682e+0	2.2886e+1	2.1434e+2