High Order Workshop Results for Case 3.3
Taylor-Green Vortex $Re = 1600$

Michael J. Brazell and Dimitri J. Mavriplis

Department of Mechanical Engineering
University of Wyoming

January 4, 2015
Flow Solver

- Unstructured Discontinuous Galerkin Finite Element Method
- Modal basis functions
- Time discretization: Runge-Kutta 4
- Compressible Navier-Stokes in conservative variables
- Inviscid flux: Lax-Friedrichs, Roe, AUFS
- Viscous flux: symmetric interior penalty (SIP)
Results

Kinetic energy for the Taylor-Green vortex at $Re = 1600$
Results

Dissipation rate $\frac{\partial E_k}{\partial t}$ for the Taylor-Green vortex at $Re = 1600$
Results

Dissipation rate $\epsilon_1$ for the Taylor-Green vortex at $Re = 1600$
Enstrophy $\mathcal{E}$ for the Taylor-Green vortex at $Re = 1600$
Results

- Dissipation error vs work units for the Taylor-Green vortex at $Re = 1600$
- Time step is fixed and based on stability of most resolved case
Results

Dissipation error vs DOF for the Taylor-Green vortex at $Re = 1600$

![Graph showing dissipation error vs DOF for different DOF values and grid points.](image-url)
Results

Iso-Contours of vorticity magnitude \( \frac{L}{V_0} |\omega| = 15, 10, 20, 30 \) at \( \frac{t}{t_c} = 8 \) and \( \frac{x}{L} = −\pi \) for the Taylor-Green vortex at \( Re = 1600 \), DG \( p = 4, \ n = 64^3 \) (red), pseudo-spectral (black)
Conclusions

- The resolved simulations match spectral closely
- $p$-refinement improves accuracy better than $h$-refinement
- Work units are reasonable considering modal basis and unstructured data structure