High-Order Workshop Results for Case MC1 High-Lift Common Research Model (HiLPW3)

Michael J. Brazell, Behzad R. Ahrabi, and Dimitri J. Mavriplis

Department of Mechanical Engineering
University of Wyoming

January 7, 2018

Flow Solver

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- Discontinuous Galerkin Finite Element Method
- Modal basis functions
- Hybrid mixed element unstructured meshes (tetrahedra, prisms, pyramids, and hexahedra)
- p-enrichment and h-refinement using non-conforming elements (hanging nodes)
- Independent polynomial degree for solution and mapping basis
- Non-linear system solver: PTC Newton-Rhapson method
- Linear system solver: preconditioned flexible-GMRES (Saad 1986)
- Line implicit Jacobi, Gauss-Seidel relaxation, ILU(0)

Physics

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- Compressible Navier-Stokes in conservative variables
- PDE-based Artificial Viscosity (Barter and Darmofal, Burgess)
- Spalart-Allmaras turbulence model (negative-SA variant)
- Inviscid flux: Lax-Friedrichs, Roe, AUFS
- Viscous flux: symmetric interior penalty (SIP)

Drag and Lift Results

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$\alpha = 8^\circ$, Roe Flux, ILU(0)

$$time/dof = \frac{cputime \times procs}{\tau \times dofs}$$

case	p	dof $\times 10^6$	C_L	C_D	time/dof
1	1	21.6	1.7763	0.17369	1.13
2	1	70.2	1.7725	0.17314	1.60
3	2	54.1	1.7868	0.17274	0.46
4	2	175.6	1.7814	0.17253	0.28

Residual, extra tiny mesh

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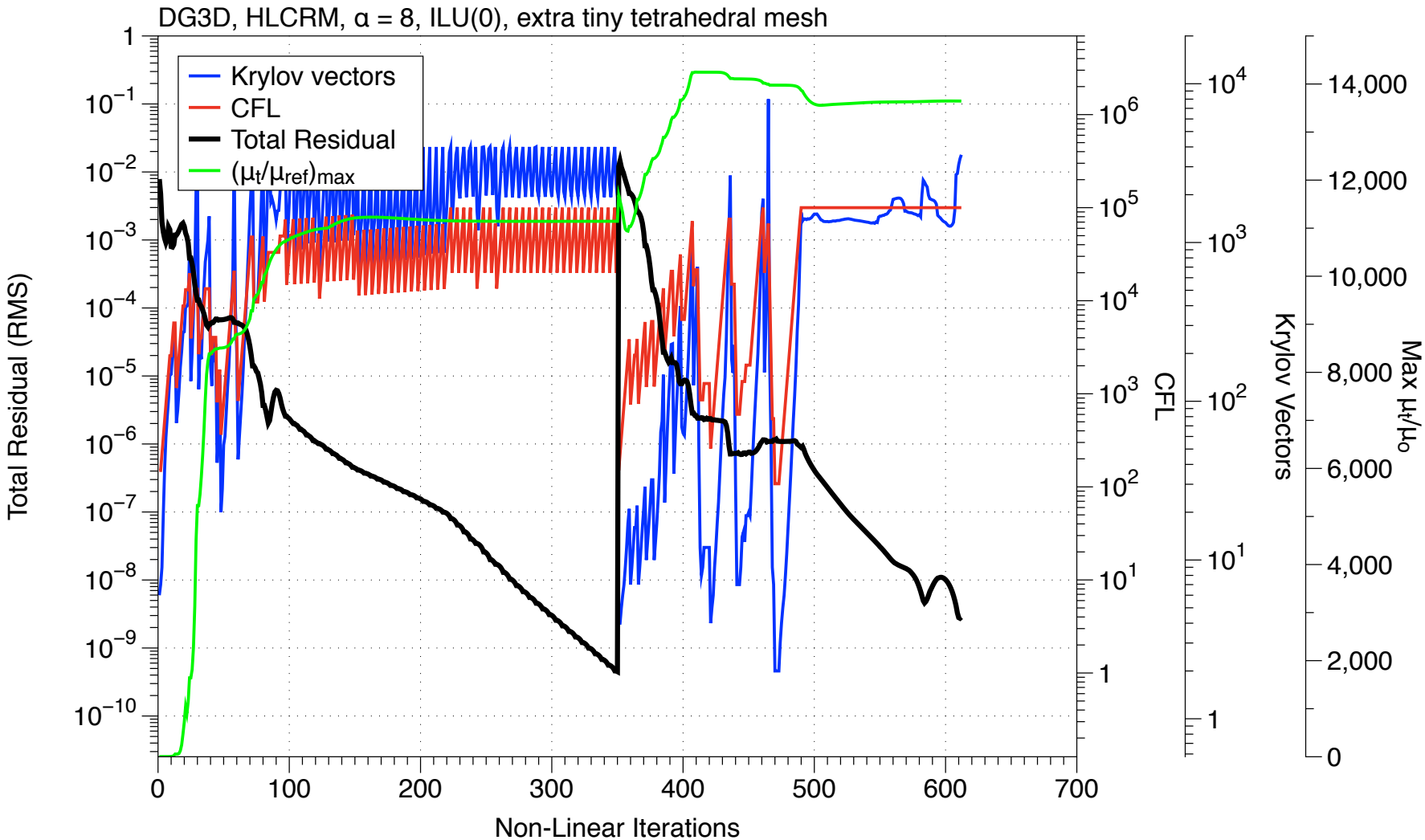
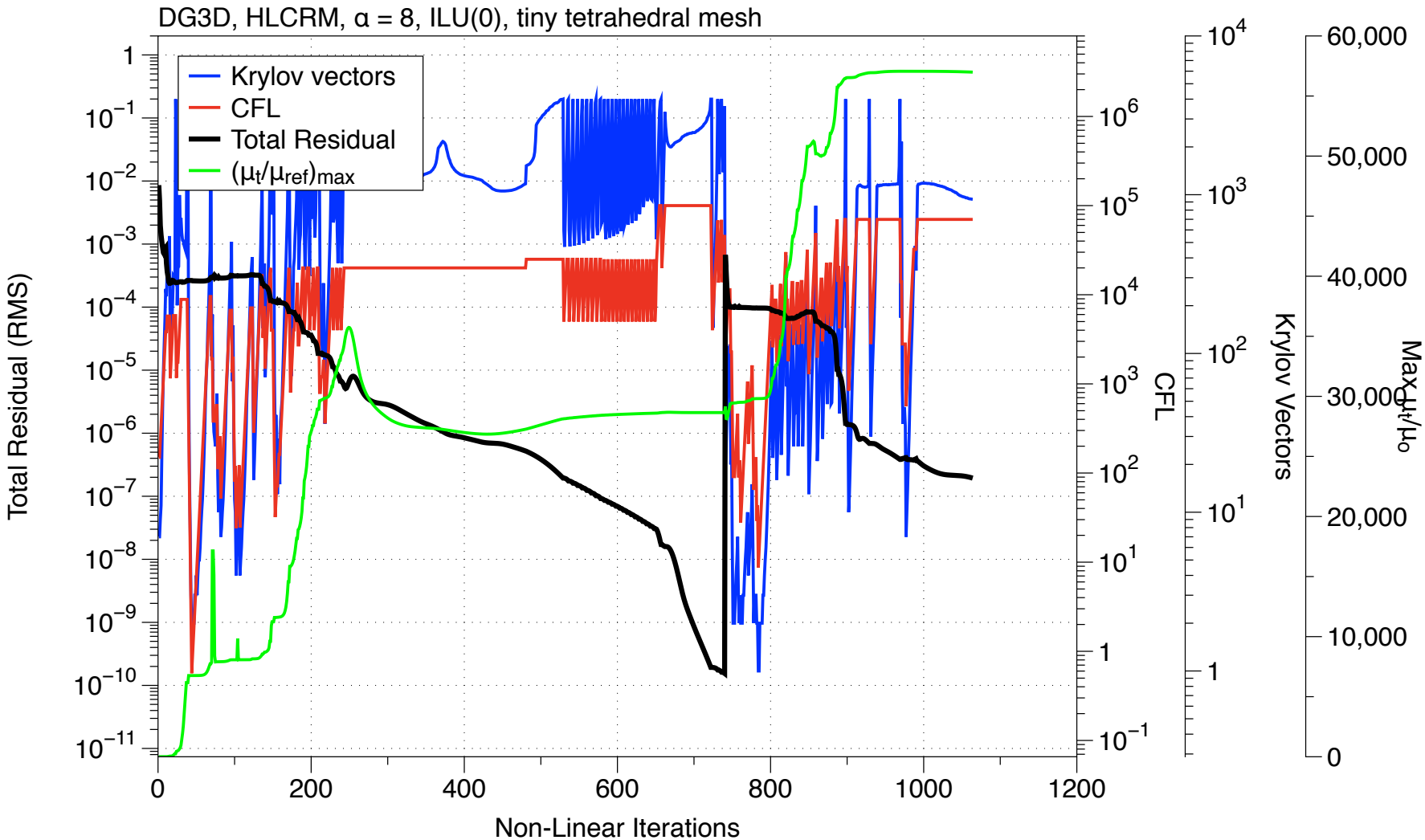


Residual, tiny mesh



Conclusions

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- Challenging case
- Not enough runs to draw any conclusions
- Initializing p=2 with p=1 still difficult and time consuming
- p=1 tetrahedral meshes are painful for DG
- If meshing goes in direction of pure tetrahedral need to develop cell-based lines that do not rely on prisms
- ILU(0) requires a lot of memory, lines will help with this but also need matrix free high-order preconditioners