On-Going Research in Drag Prediction

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OUTLINE

- **ADJOINT RECOVERY OF SUPERCONVERGENT FUNCTIONALS**
  - Niles Pierce, Caltech
  - Mike Giles, Oxford
- **GRID ADAPTATION & ADJOINT ERROR ESTIMIATION**
  - David Venditti, MIT
  - David Darmofal, MIT

PIERCE & GILES

- **ADJOINT RECOVERY**
  - Solve Both the Primal and Adjoint PDEs
  - Estimate Sensitivity of Grid on Primal Solution
  - Improve Result of a Boundary Integration
    - Boundary Integration is Superconvergent
  - Provides an Error Bound
    - Currently, Only Proven for Linear PDEs
    - Currently, Working on the Non-Linear Problem

PIERCE & GILES

REFERENCES

Pierce, N.A. & Giles, M.B., "Adjoint Recovery of Superconvergent Functionals from PDE Approximations," SIAM Review, Vol. 42, No. 2, pp. 247-264, April, 2000.

Mueller, J.D. & Giles, M.B., "Solution Adaptative Mesh Refinement Using Adjoint Error Analysis," AIAA Paper 2001-2550, CFD Conference, Anahiem, CA, June, 2001.

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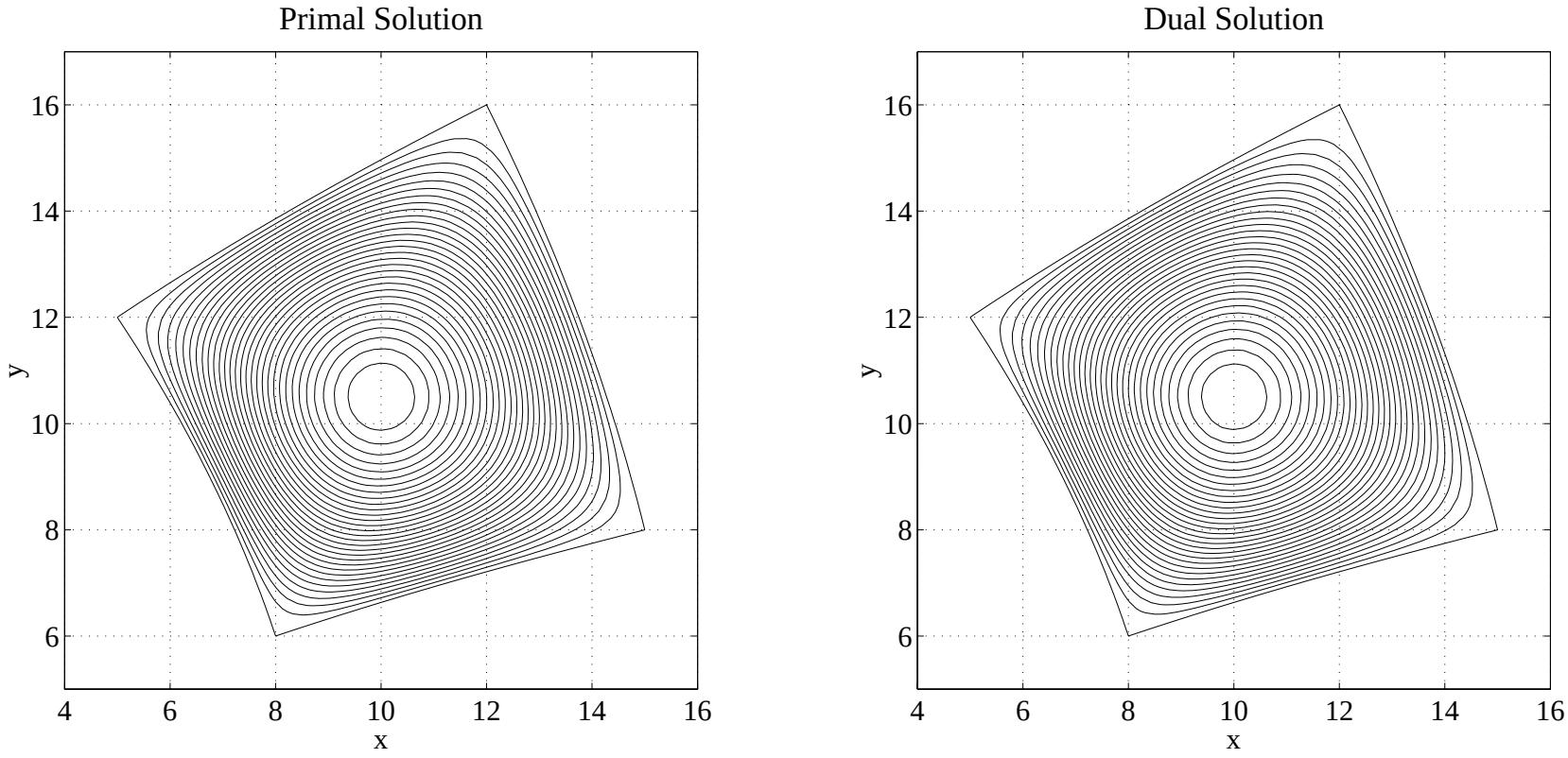

2D Poisson Equation on Warped Square

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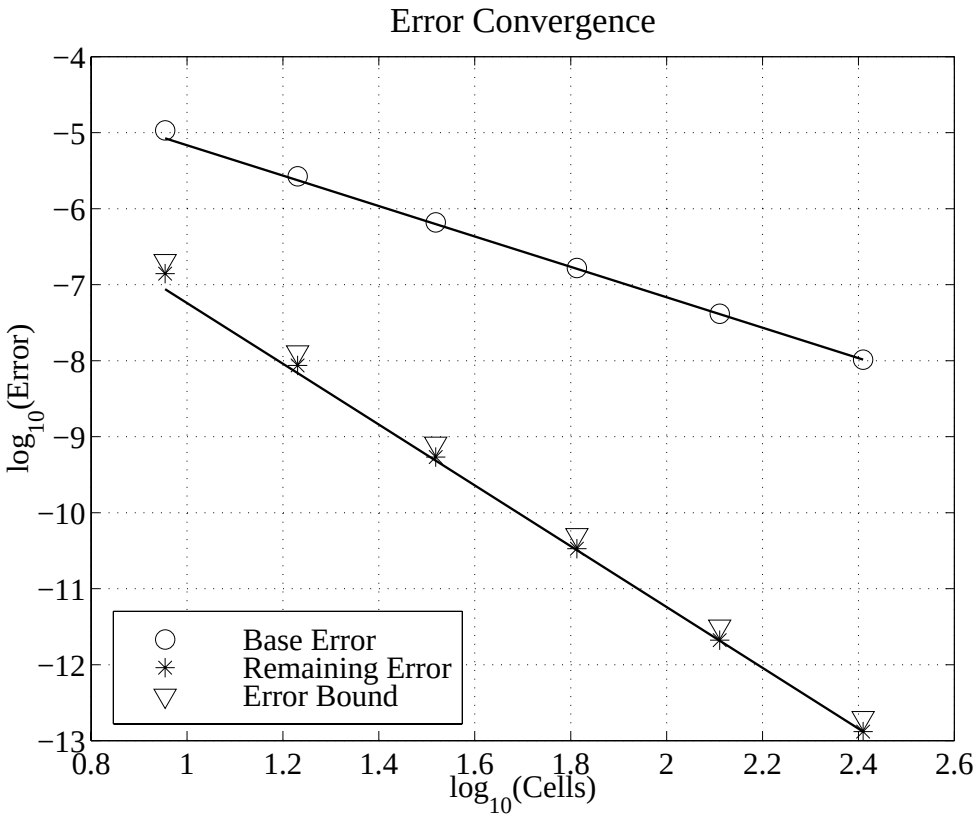

2D Poisson Equation with Bulk Funcitional

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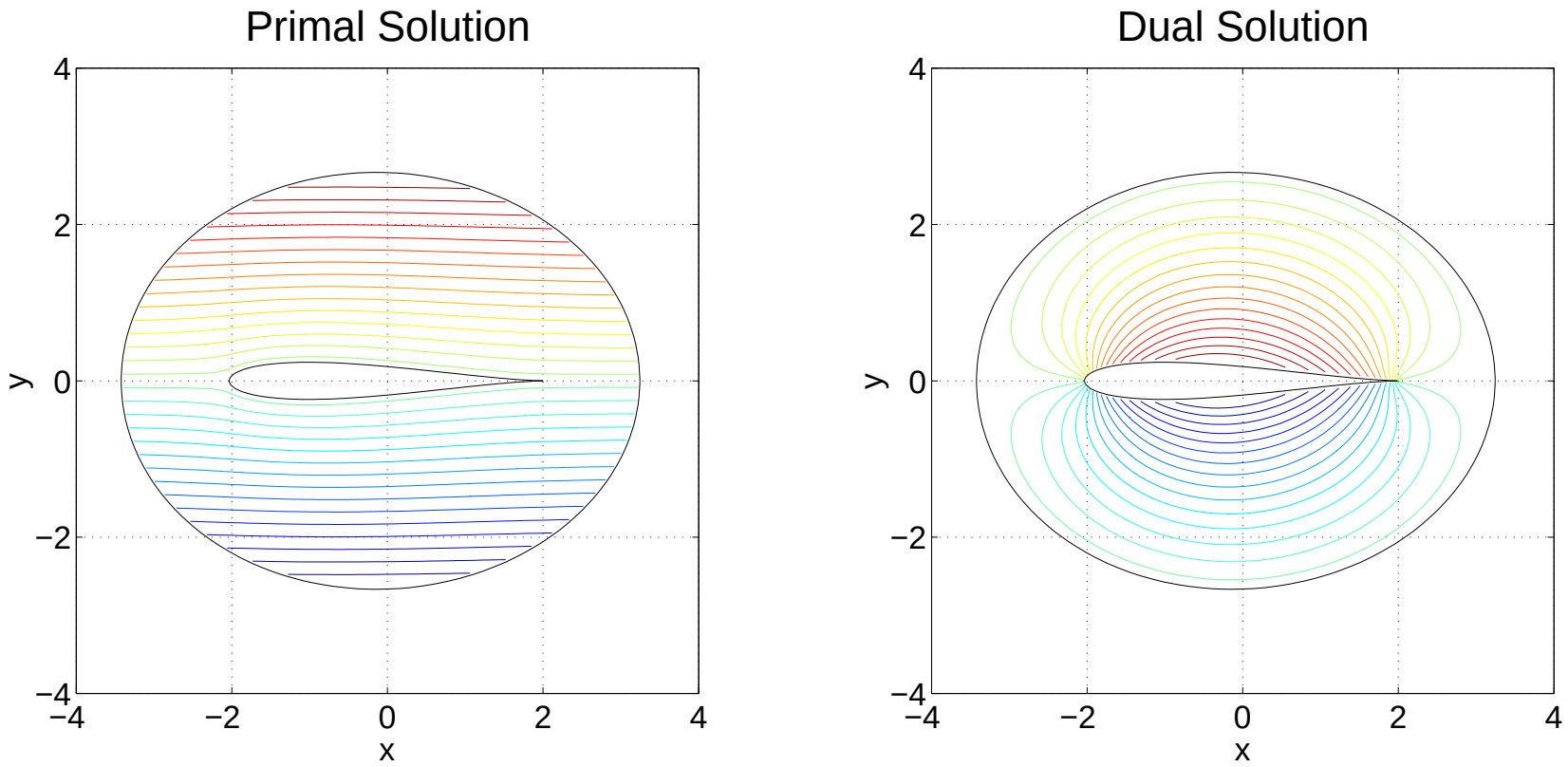

2D Laplace Equation on Joukowski Airfoil

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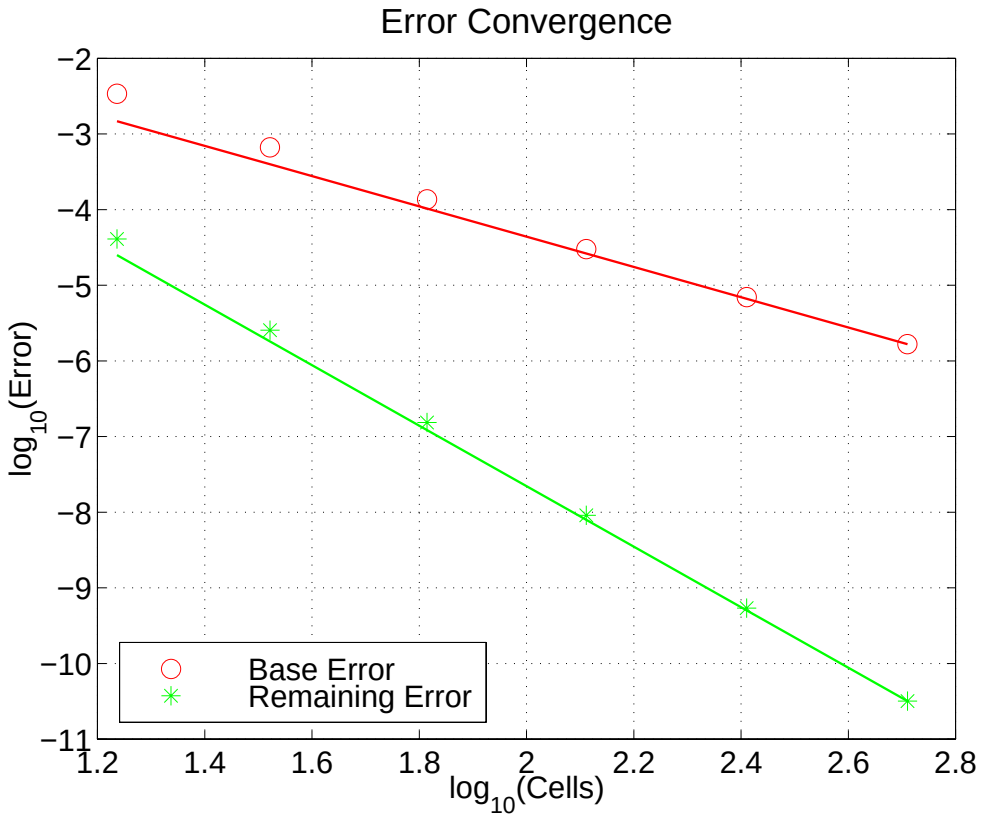


2D Laplace Equation with Boundary Functional

VENDITTI & DARMOFAL

- **GRID ADAPTATION & ADJOINT ERROR ESTIMATION**
  - Solve Both the Primal and Adjoint PDEs
  - Project Both Solutions to a Finer Grid
  - Estimate Local Error of Primal Solution
  - Adapt Grid until Local Error is Globally Uniform
  - Comparisons with Adhoc Sensors
    - 2D Advanced EET High-Lift Configuration
    - 2D Staggard Supersonic Bi-Plane

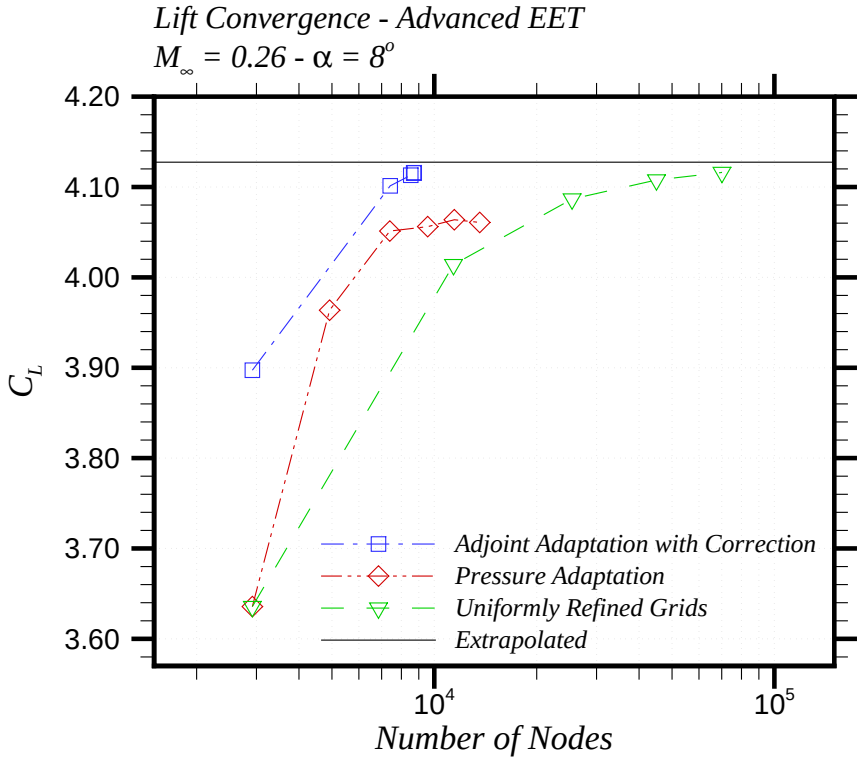
VENDITTI & DARMOFAL

REFERENCES

Venditti, D. & Darmofal, D., "An Adaptive Unstructured Methodology for Functional Outputs of Compressible Flow Simulations," AIAA Paper 2001-2659, CFD Conference, Anahiem, CA, June, 2001.

Venditti, D. & Darmofal, D., "A Multilevel Error Estimation and Grid Adaptation Strategy for Improving the Accuracy of Integral Outputs," AIAA Paper 99-3292, CFD Conference, Norfolk, VA, 1999.

VENDITTI & DARMOFAL



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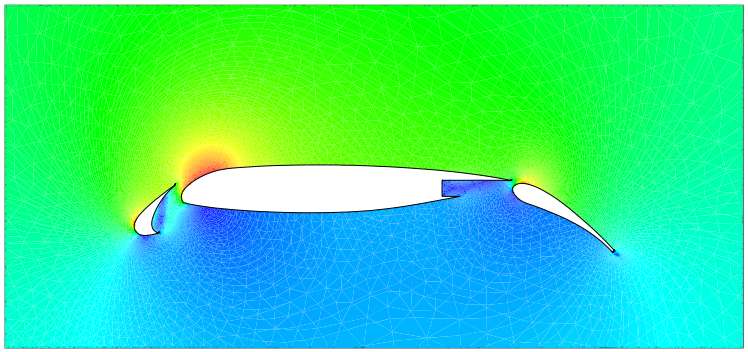
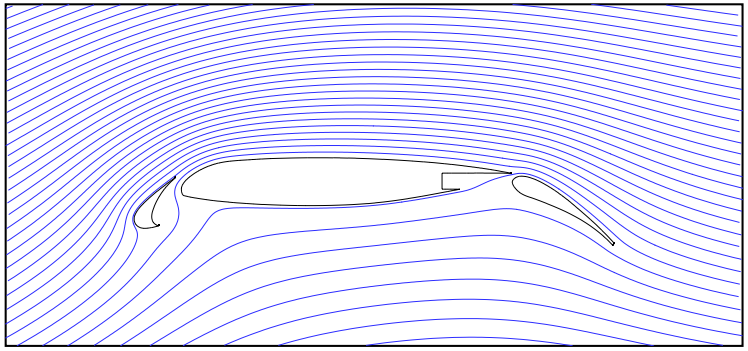
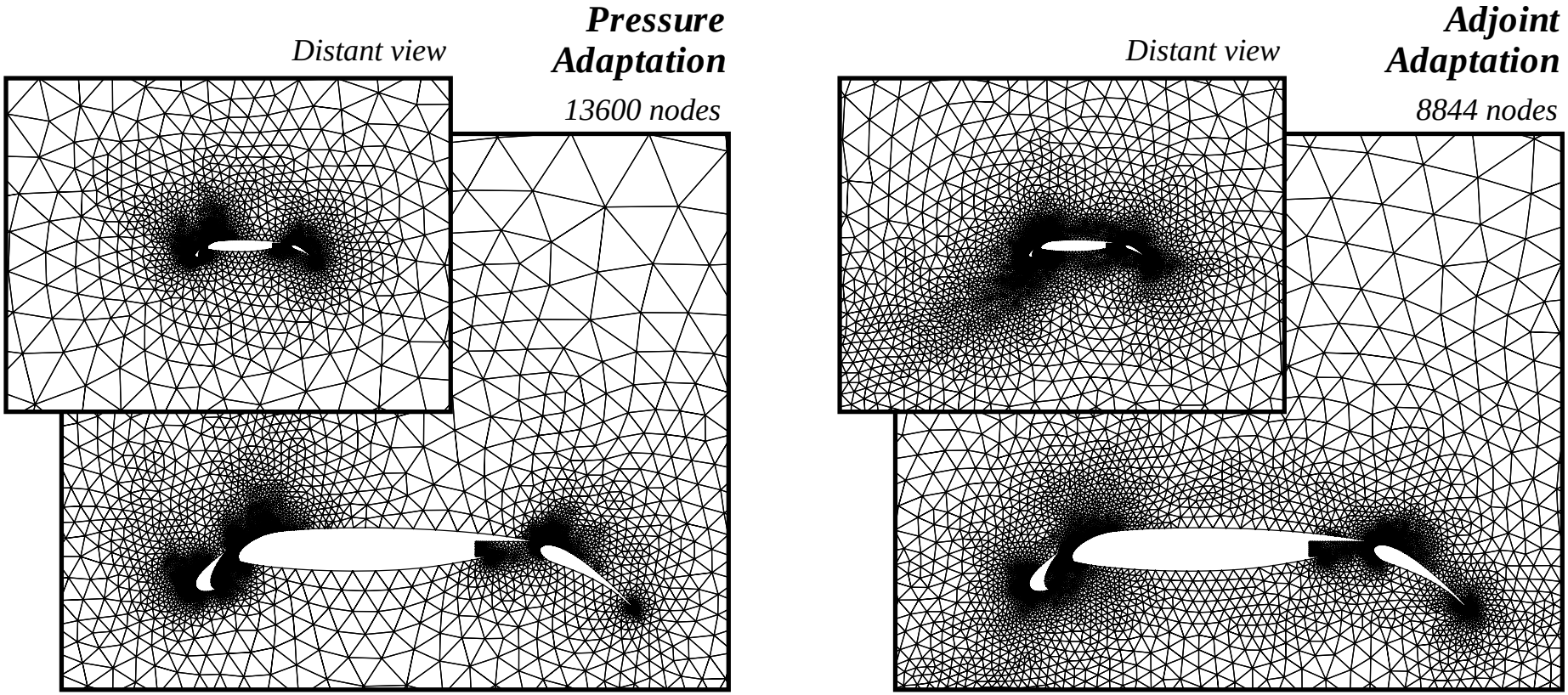


Streamlines



Advanced EET High-Lift Airfoil

VENDITTI & DARMOFAL



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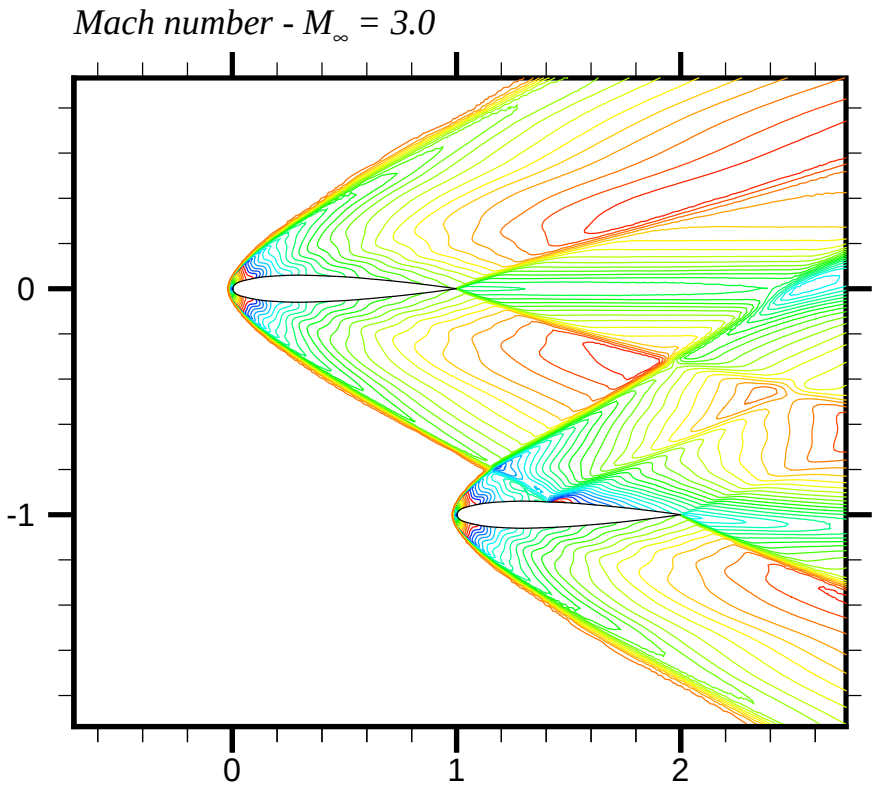

2D Staggard Supersonic Bi-Plane

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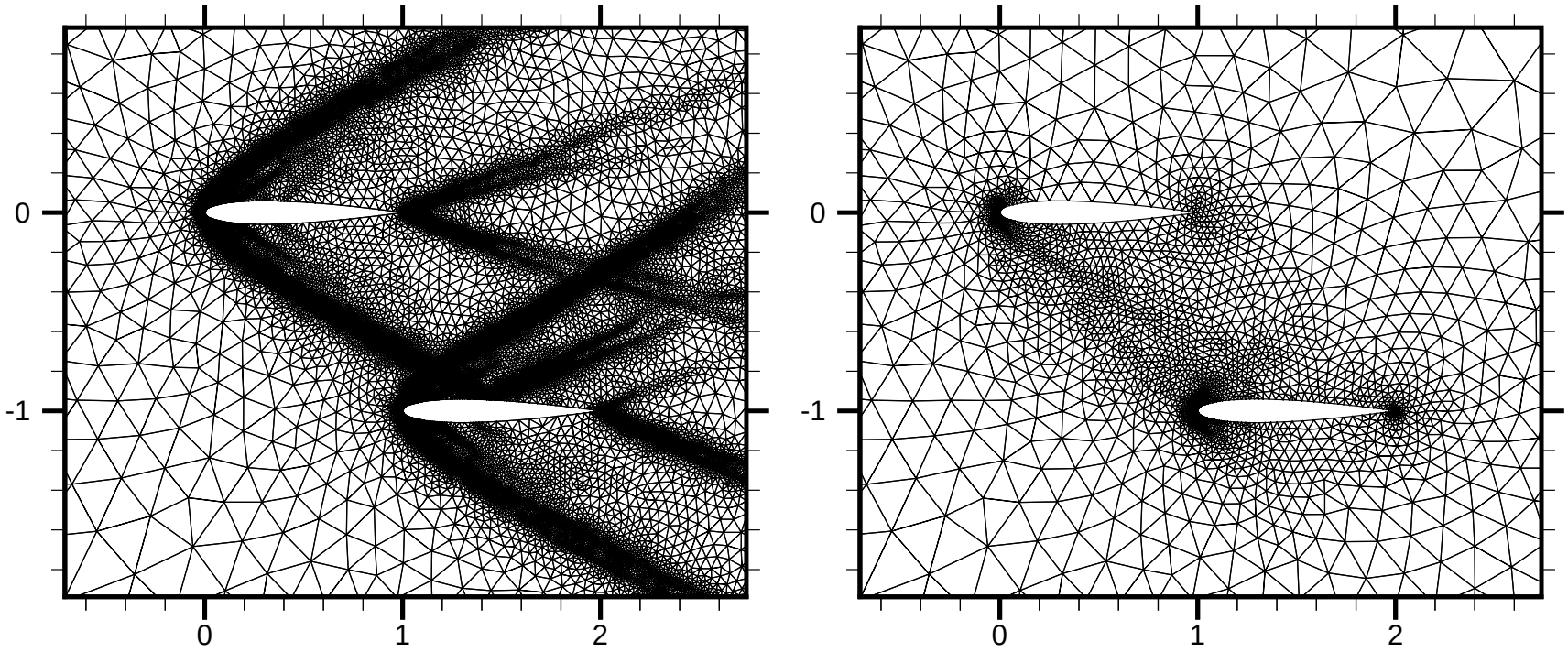
Pressure-based adaptation
C_D = 0.0767 (lower airfoil)

Final grid
37352 Nodes

Adjoint-based adaptation
C_D = 0.0766 (lower airfoil)

Final grid
3810 Nodes



2D Staggard Supersonic Bi-Plane