Compressible aerodynamics using modern high-order methods

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Compressible Aerodynamics (CA) group

G. Mengaldo	2D - 2.5D high-order methods / BL transition
D. De Grazia	3D high-order methods / BL transition
D. Ekelschot	3D goal-based error estimator (adjoint)
D. Moxey	Applicability of high-order methods in aeronautics

Contents

1. Introduction
2. Some results
3. Final remarks

Contents

Focus on

Developing high-order methods

Focus on

Developing high-order methods

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Discontinuous Galerkin (DG) - Flux Reconstruction (FR)

Focus on

Developing high-order methods

↓

Discontinuous Galerkin (DG) - Flux Reconstruction (FR)

Linear/Nonlinear ⟷

- Hyperbolic problems
- Parabolic problems
- 'Mixed' problems

Focus on

- Unsteady advection/diffusion equations

Numerics research

- Compressible Euler equations
- Compressible Navier-Stokes equations

Aerodynamics research

Main objectives

High-order accuracy

Performance

Capture all features of compressible problems

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High-order accuracy

Performance

Capture all features of compressible problems

↓

Effective DNS tool for compressible aerodynamics

Contents

Unsteady Advection equation

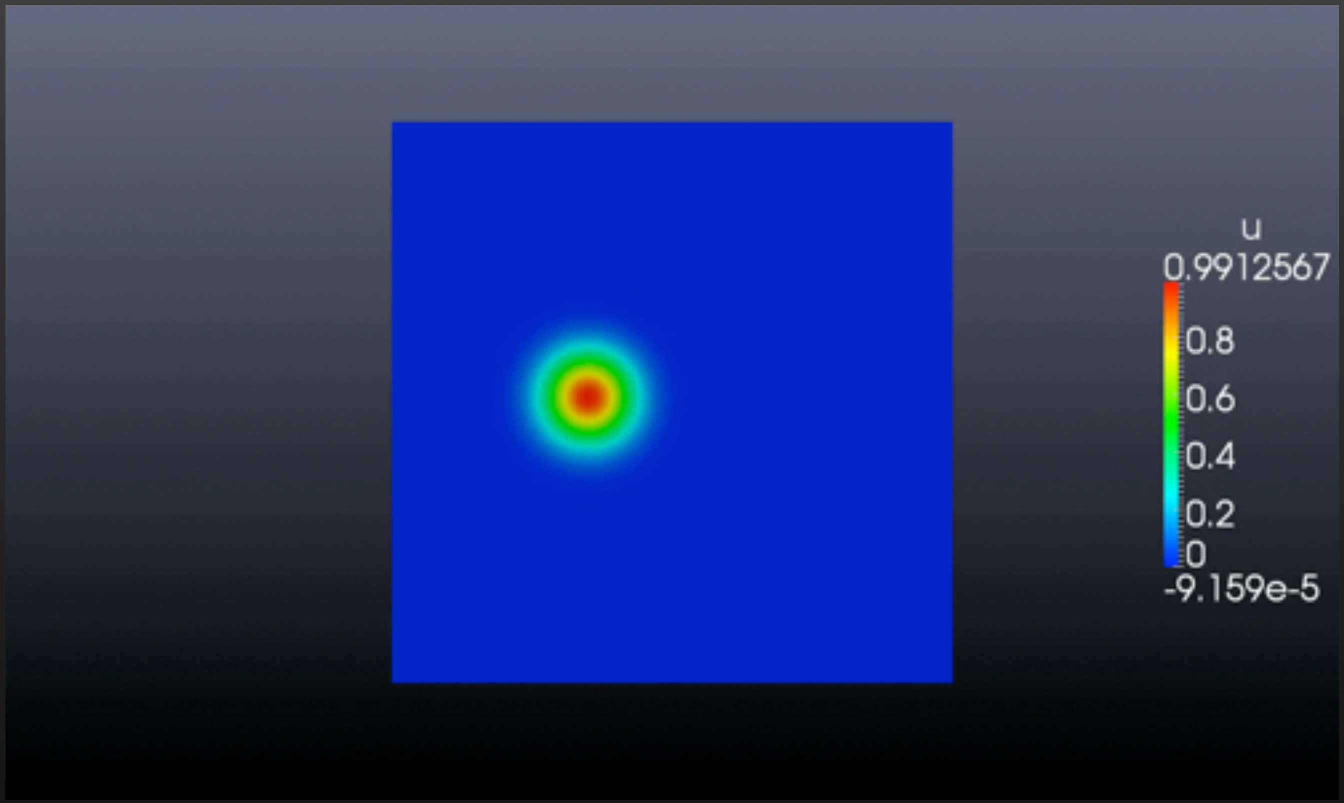
1D/2D DG/FR - 3D DG ✓

Unsteady Advection equation

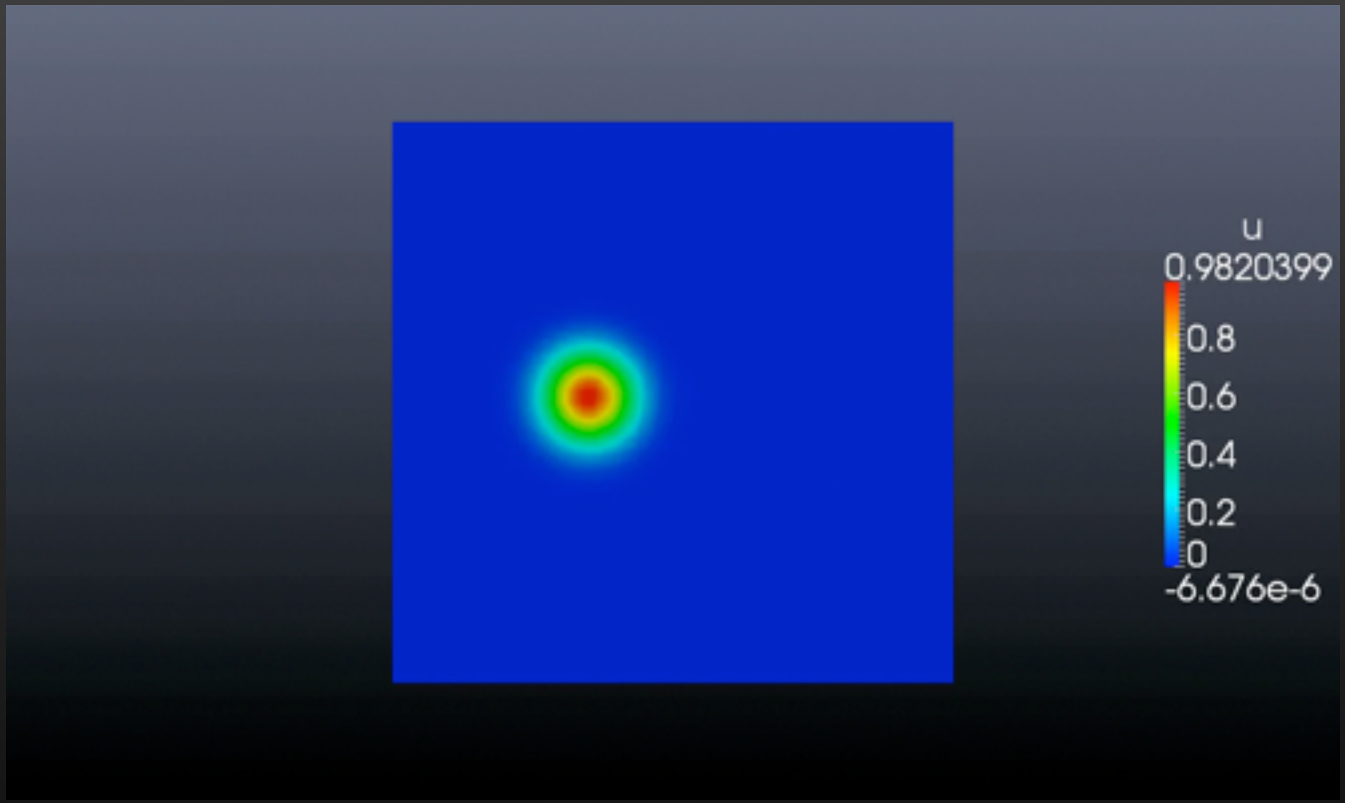
1D/2D DG/FR - 3D DG ✓

Unsteady Advection equation

1D/2D DG/FR - 3D DG ✓



Regular grid



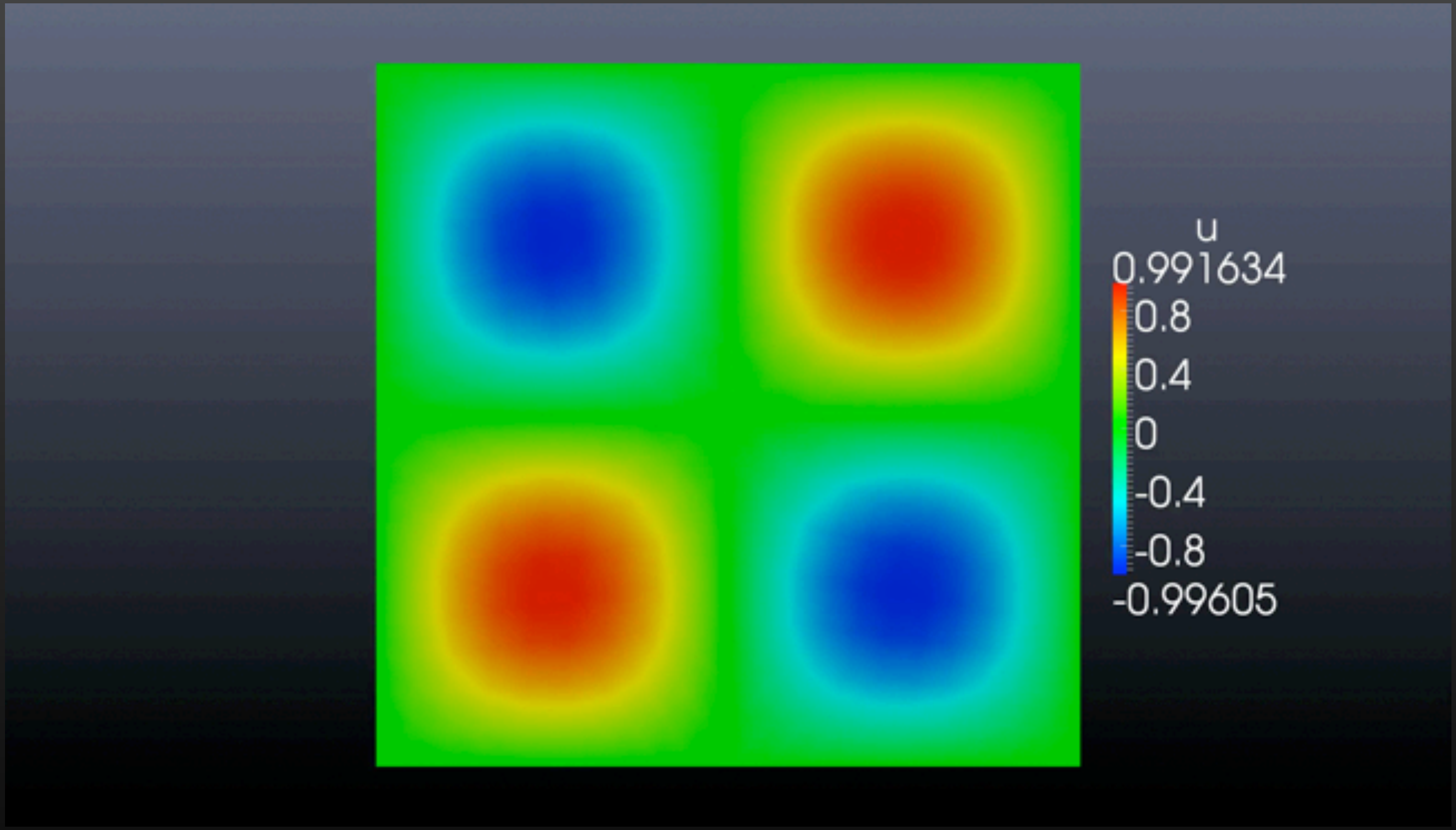
Deformed grid

Unsteady Diffusion equation

1D/2D DG/FR - 3D DG ✓

Unsteady Diffusion equation

1D/2D DG/FR - 3D DG ✓



Compressible Euler equations

1D/2D DG/FR - 3D DG ✓

Compressible Euler equations

1D/2D DG/FR - 3D DG ✓

Compressible Euler equations

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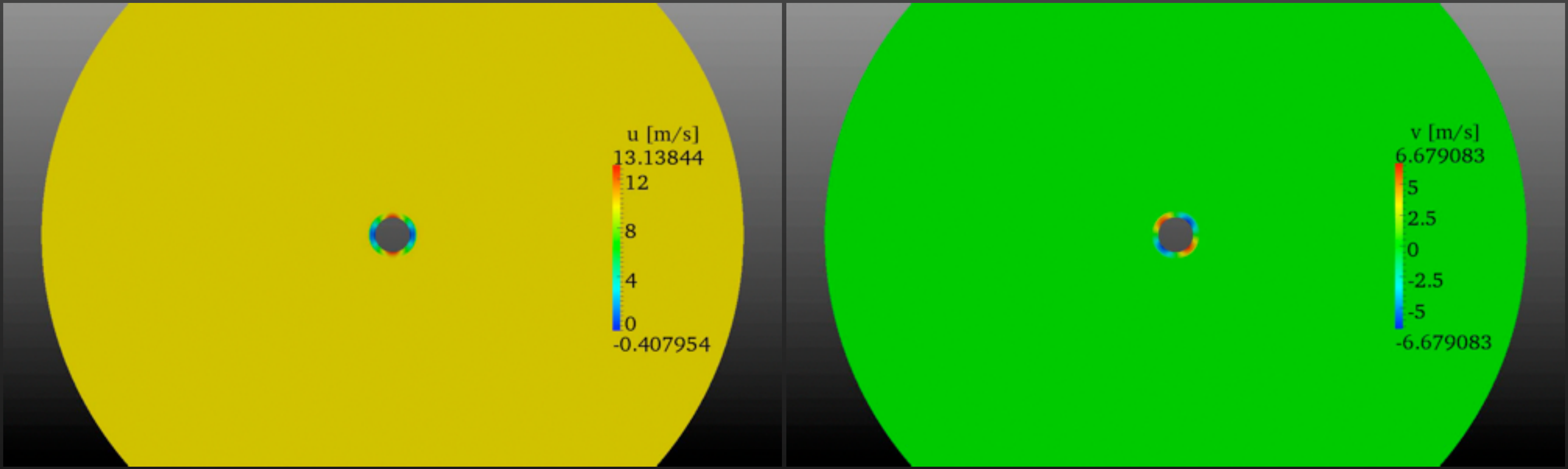
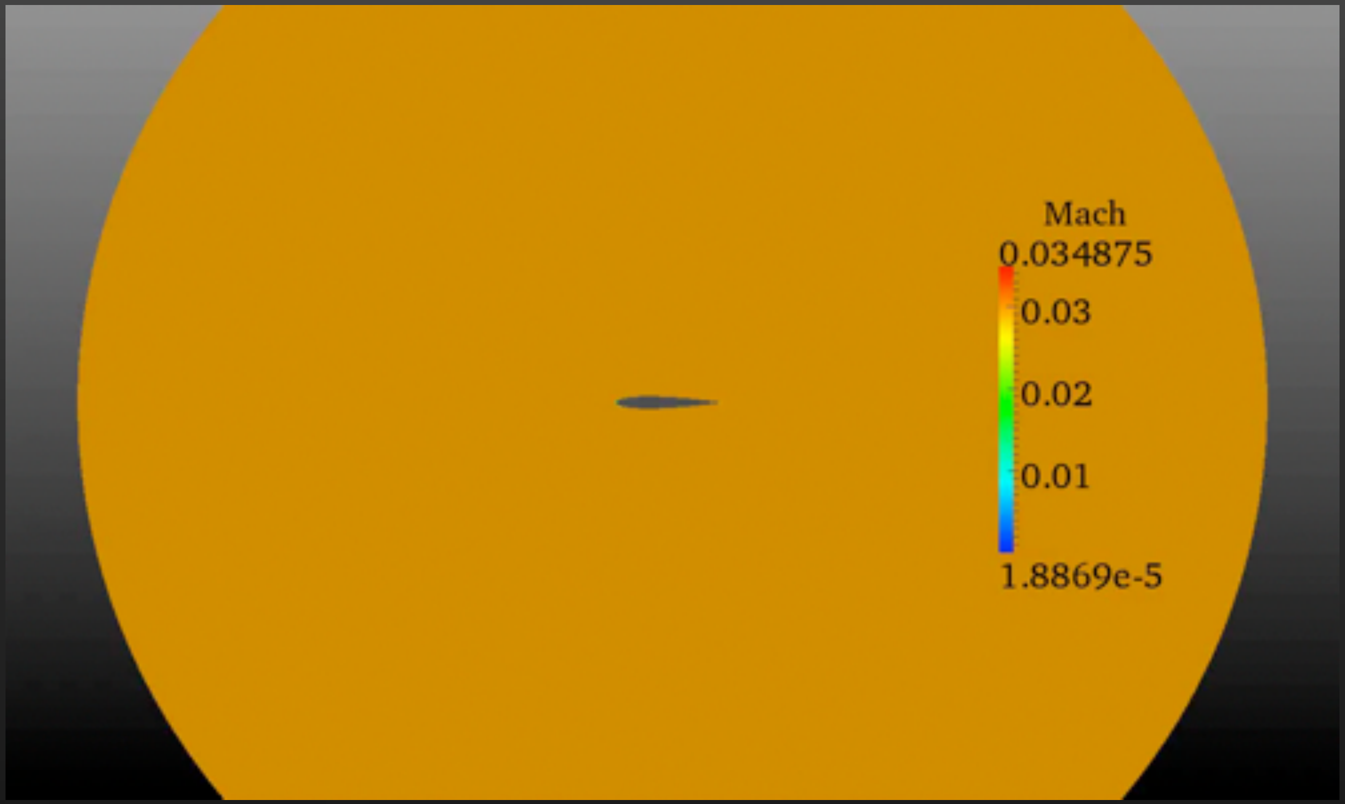


u [m/s] v [m/s]

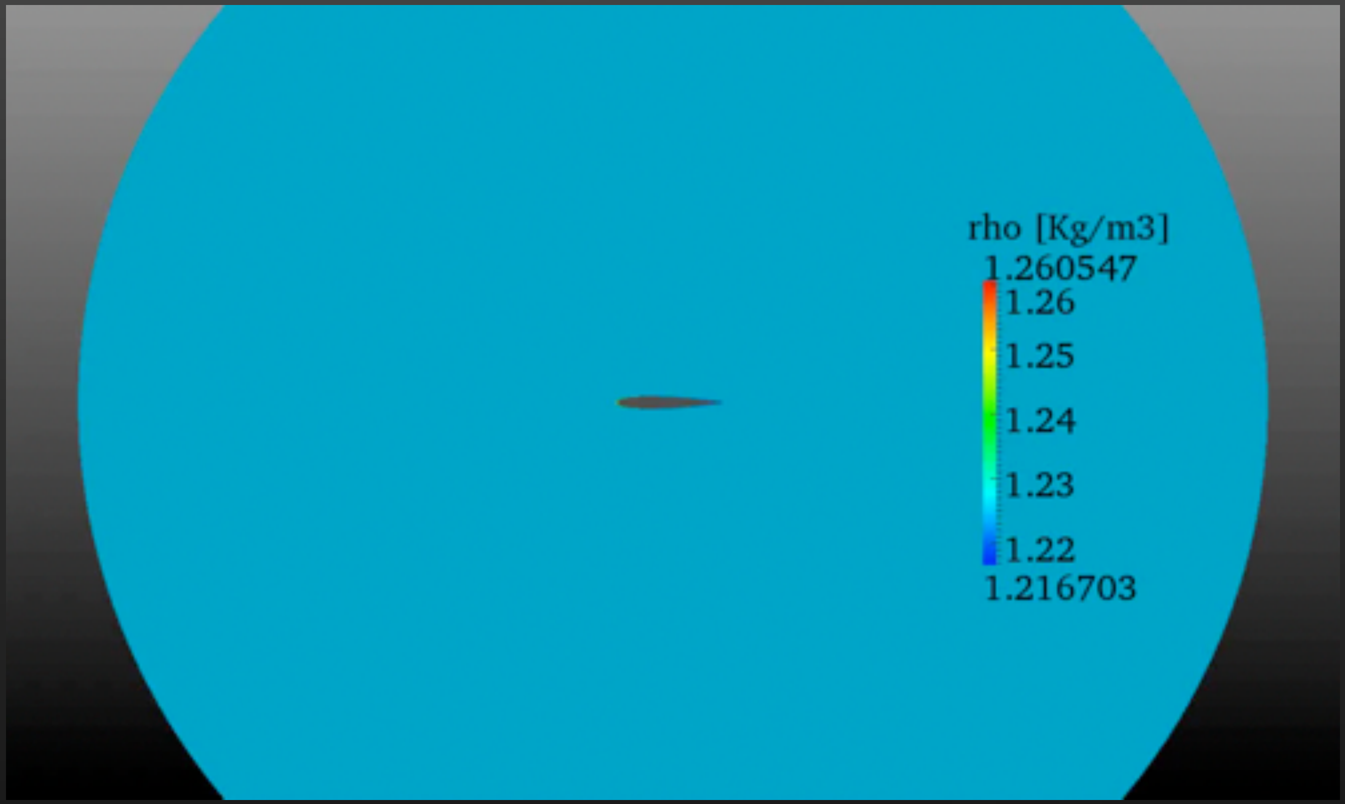
$$M_\infty \approx 0.033$$

Compressible Euler equations

1D/2D DG/FR - 3D DG ✓



Mach [-]



Density [Kg/m3]

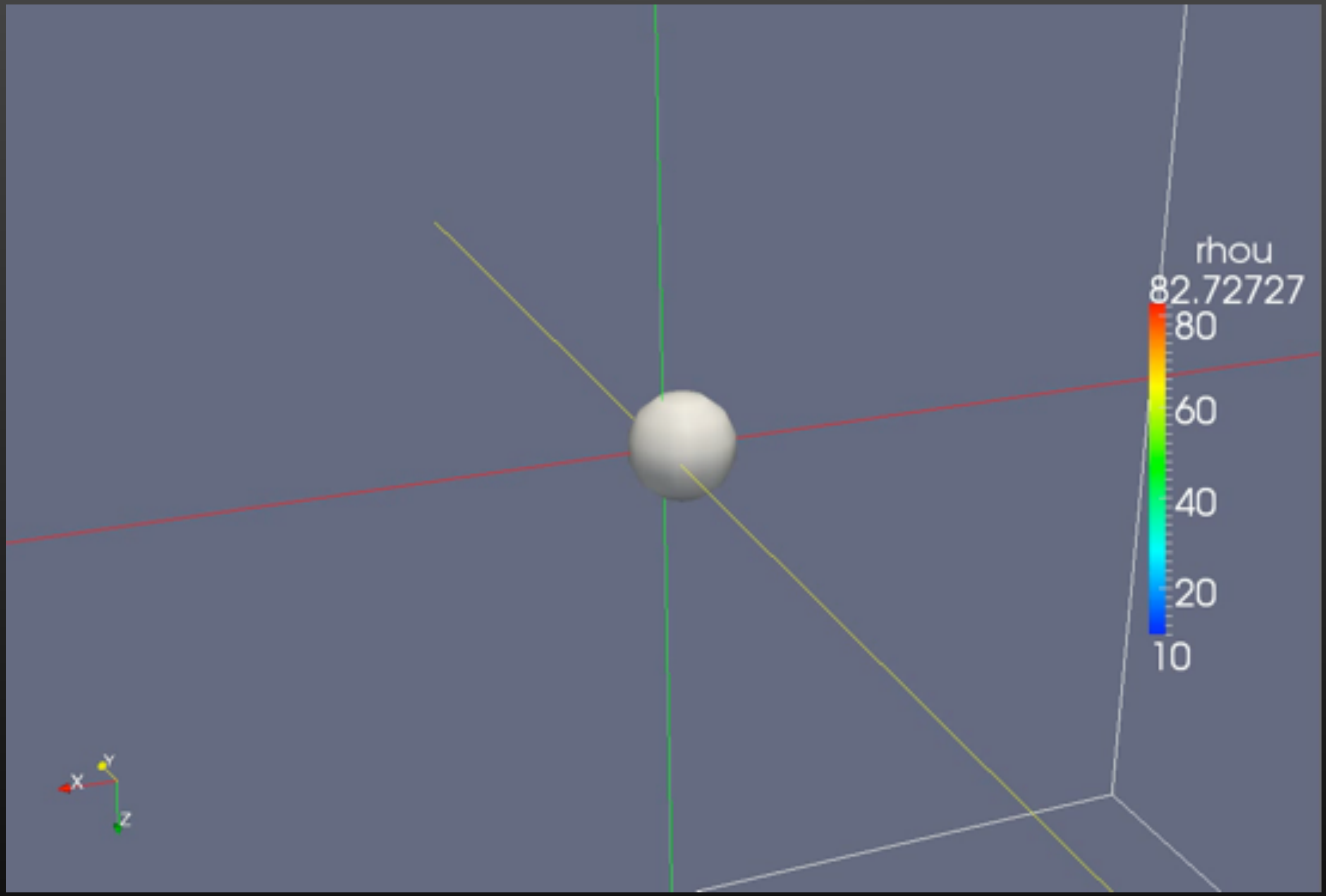
$$M_\infty \approx 0.033$$

Compressible Euler equations

1D/2D DG/FR - 3D DG ✓

Compressible Euler equations

1D/2D DG/FR - 3D DG ✓



$$M_\infty = 0.147$$

Compressible NS equations

1D/2D DG/FR - 3D DG ✓

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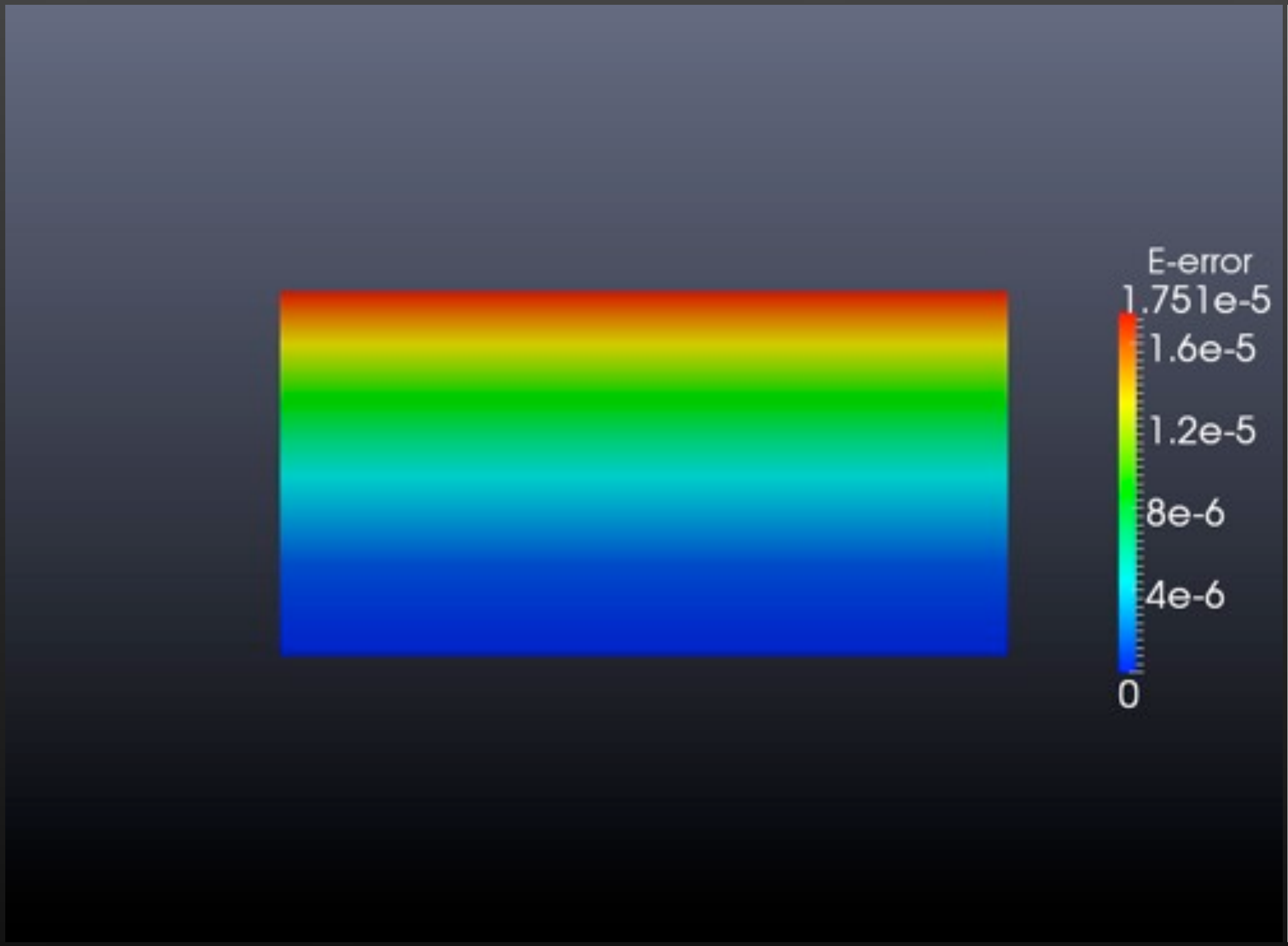

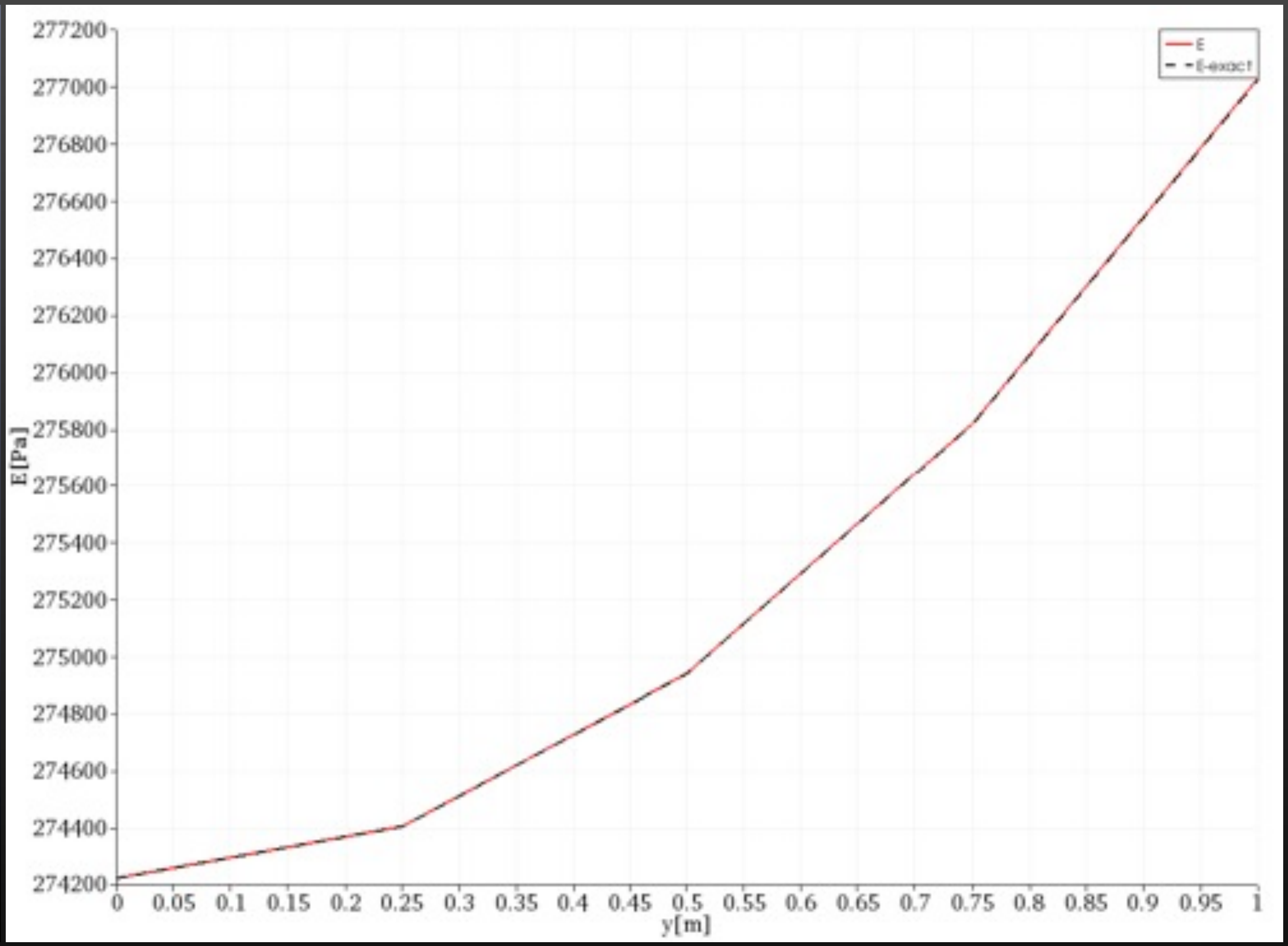

Couette flow - Energy [Pa]

Compressible NS equations

1D/2D DG/FR - 3D DG ✓

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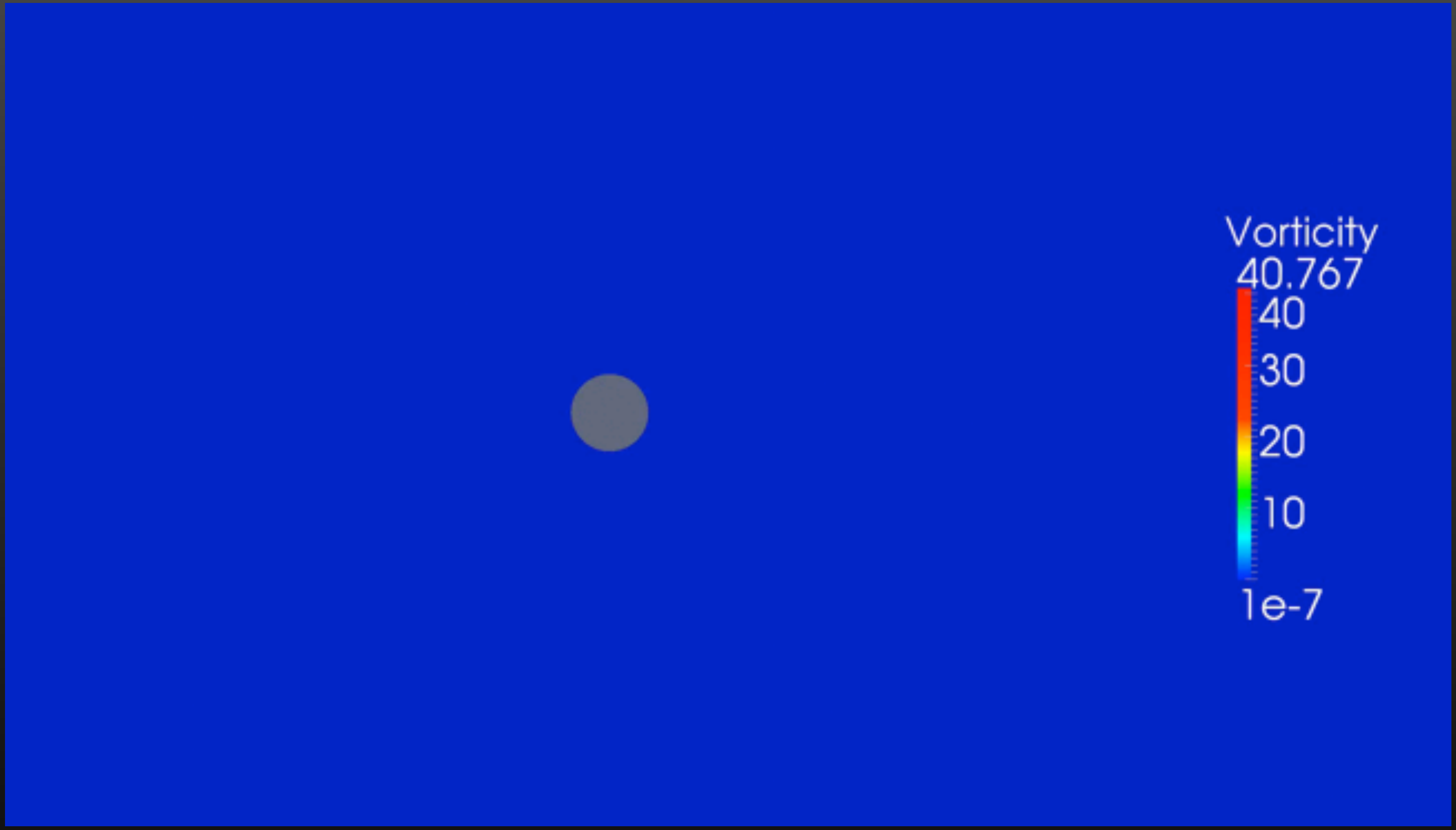
1D/2D DG/FR - 3D DG ✓



Flow past a cylinder - Vorticity [1/s]

P-adaption (Unsteady Advection)

2D DG/FR - 3D DG ✓

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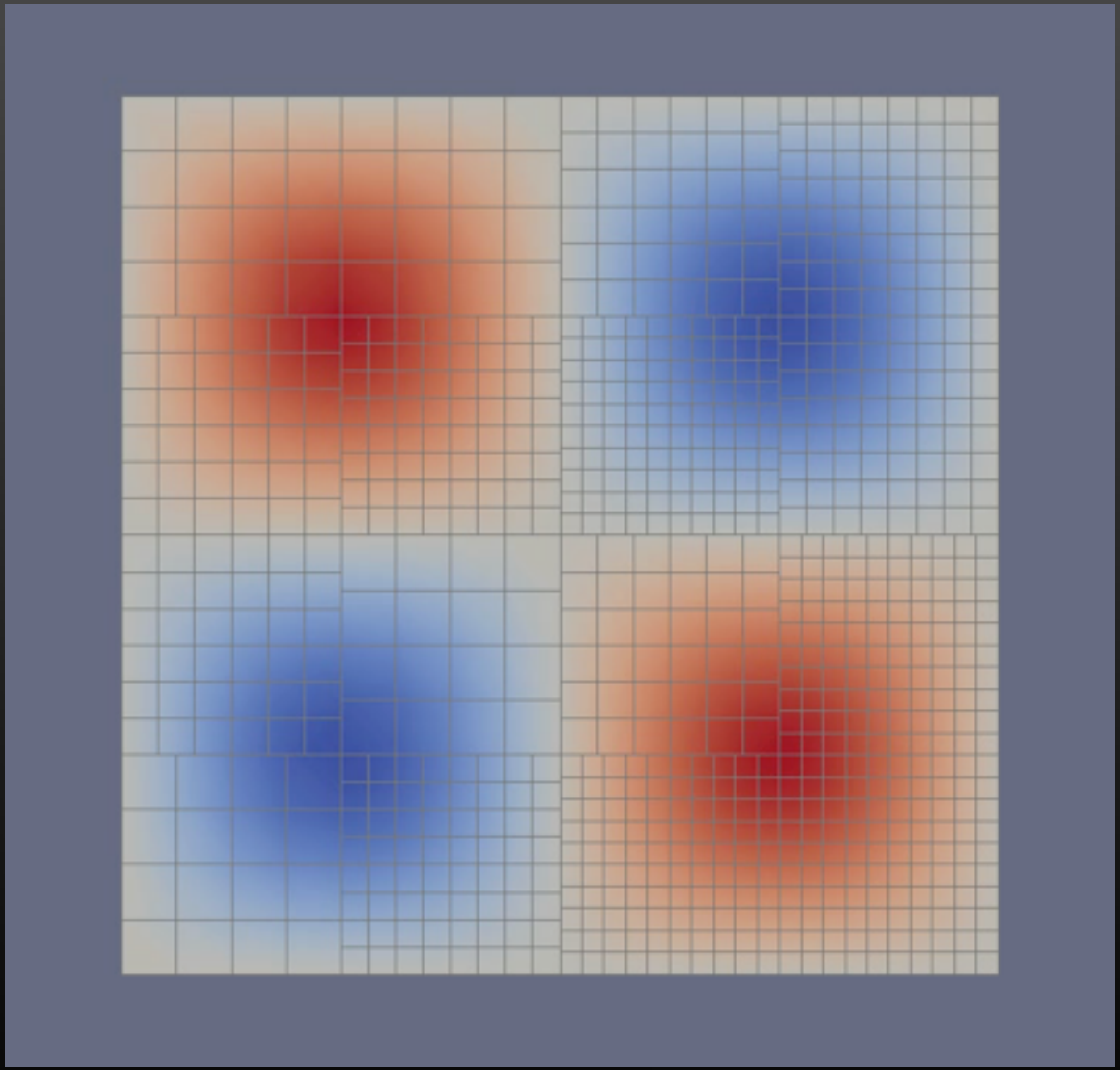

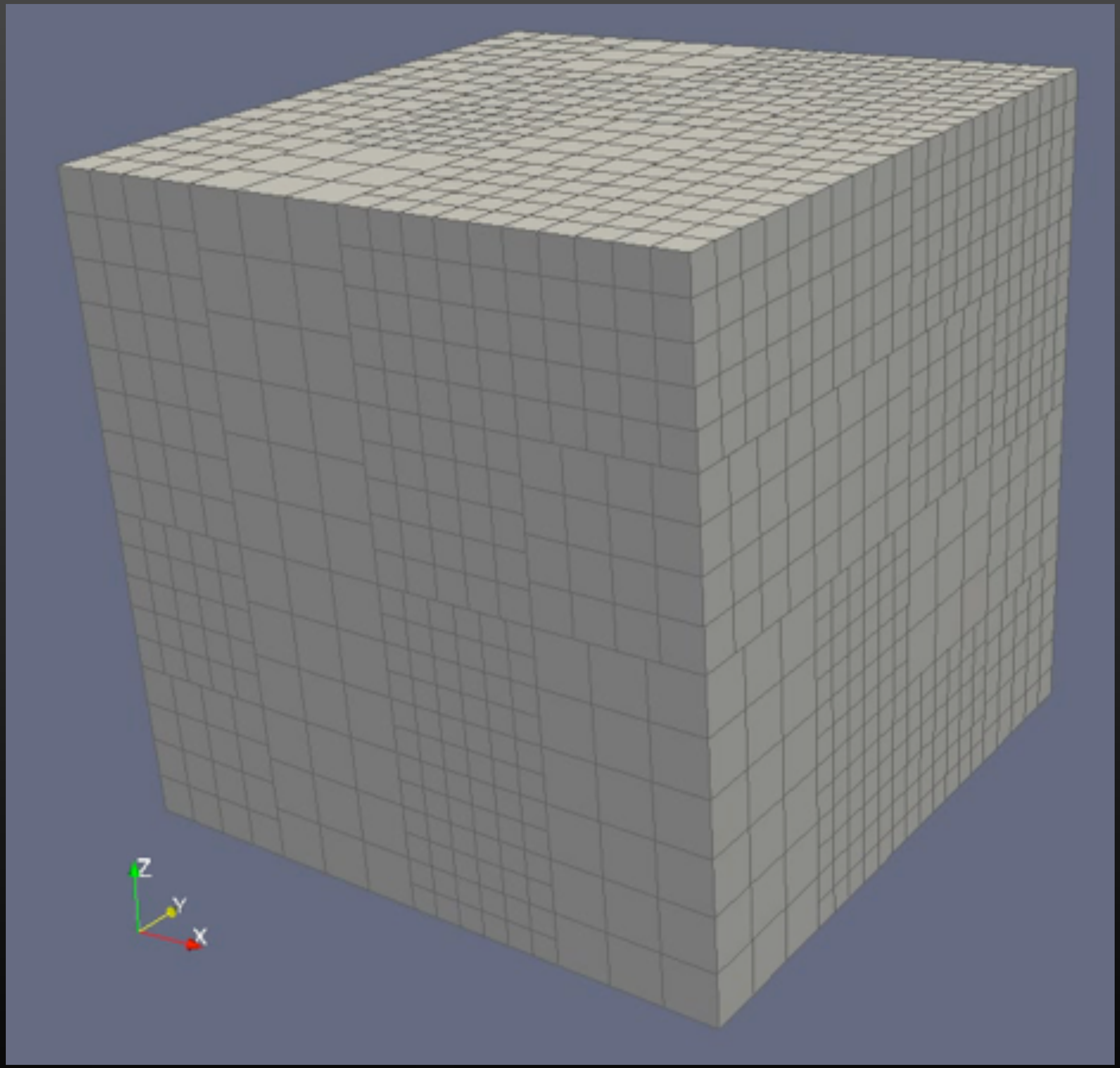

P-adaption (Euler equations)

2D DG/FR - 3D DG ✓

P-adaption (Euler equations)

2D DG/FR - 3D DG ✓

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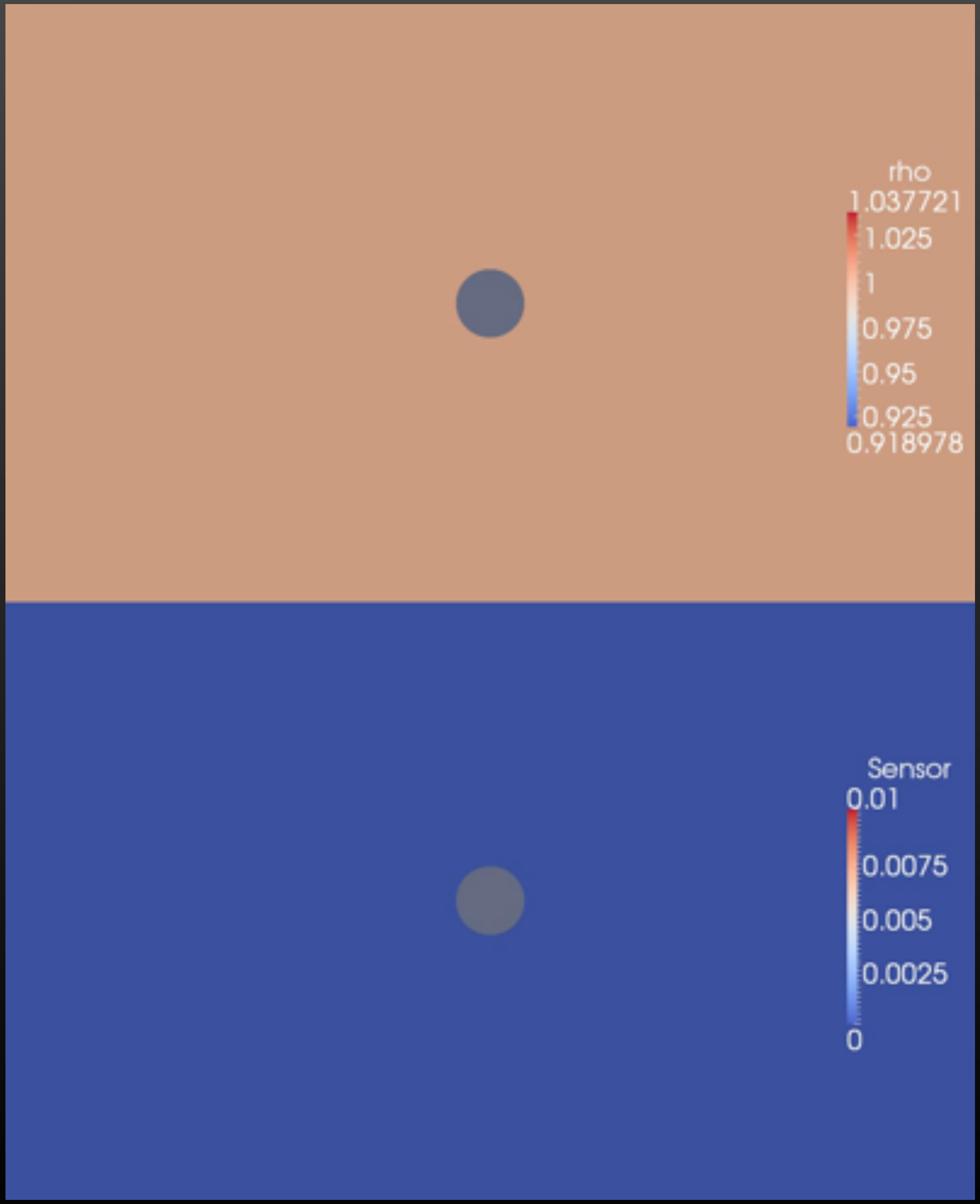
2D DG/FR - 3D DG ✓



Contents

Summary

1D/2D/3D DG method (various shapes)

1D/2D FR method (quadrilaterals)

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1D/2D FR method (quadrilaterals)

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Unsteady advection/ diffusion problems ✓

Compressible Euler/Navier-Stokes equations

Summary

1D/2D/3D DG method (various shapes)

1D/2D FR method (quadrilaterals)

→

Unsteady advection/ diffusion problems

Compressible Euler/Navier-Stokes equations

✓

2D/3D sensor and variable P ✓

Parallelisation (except periodic BCs) ✓

Next 3-month steps

Non-reflective boundary conditions (Gianmarco)

3D - Homogeneous 1D (David - Gianmarco)

3D FR (Daniele)

Turbulence simulations (David)

(2D/3D) Shock capturing methods (Dirk)

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