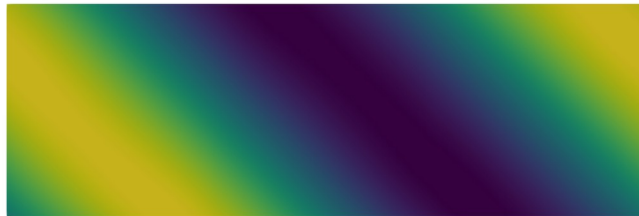
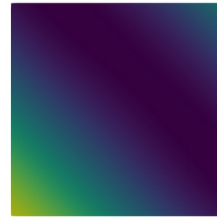
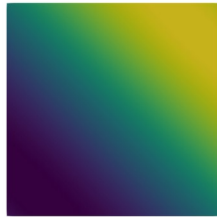


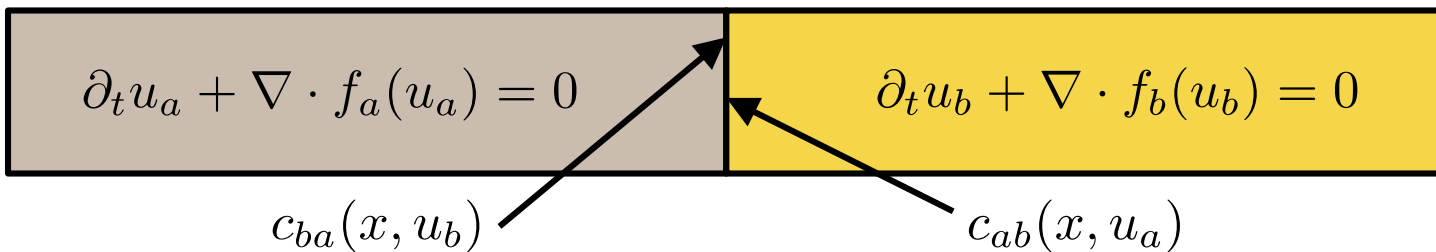
Multiphysics Coupling and Adaptive Model Selection Using p4est Meshes in Trixi.jl

Simon Candelaresi, Michael Schlottke-Lakemper



Coupling via Converter Functions

Two system with any number of shared variables, including 0:



2.5d MHD $\rho, v_1, v_2, v_3, p, B_1, B_2, B_3, \Psi$

ρ, v_1, v_2, p 2d Euler

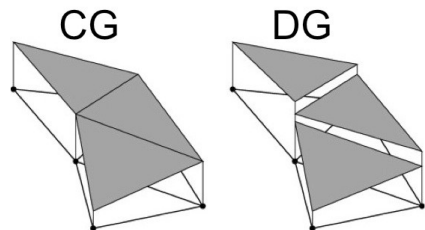
```
coupling_function12 = (x, u, equations_other, equations_own)
                     -> SVector(u[1], u[2], u[3], 0.0, u[4], 0.0, 0.0, 0.0, 0.0)
coupling_function21 = (x, u, equations_other, equations_own) -> SVector(u[1], u[2], u[3], u[5])
```

⇒ User can define converter functions.

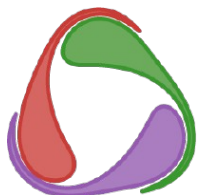
⇒ Any pair of systems can be coupled.

Trixi.jl

Discontinuous Galerkin

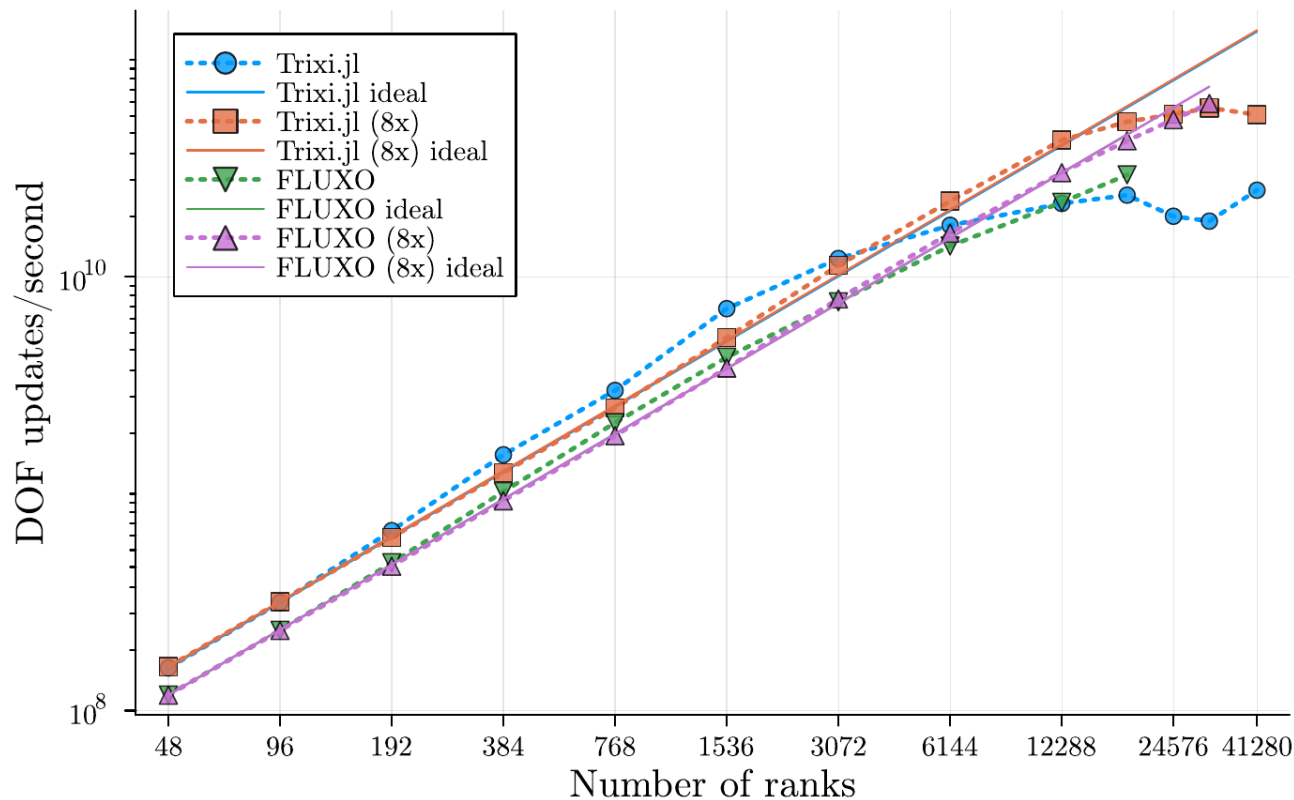


(Stack Overflow)



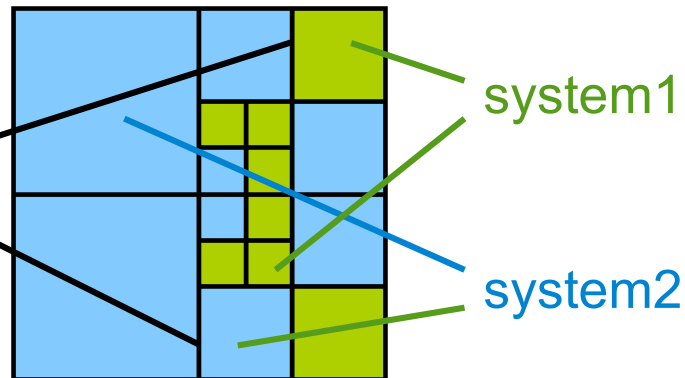
OrdinaryDiffEq (SciML)

DUPS on JUWELS Booster (strong scaling, 262144 elements, $p=3$)



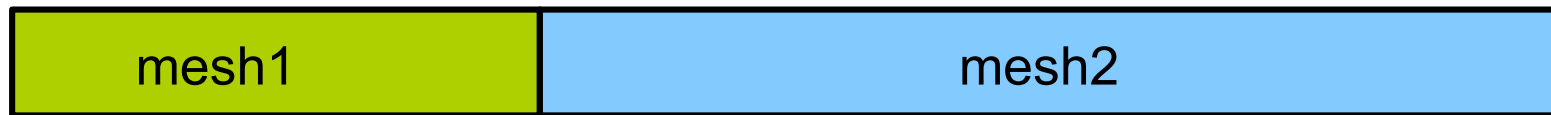
p4est Meshes

We can define the b.c. for each cell boundary.

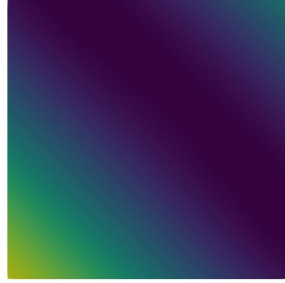


parent mesh

mesh views:



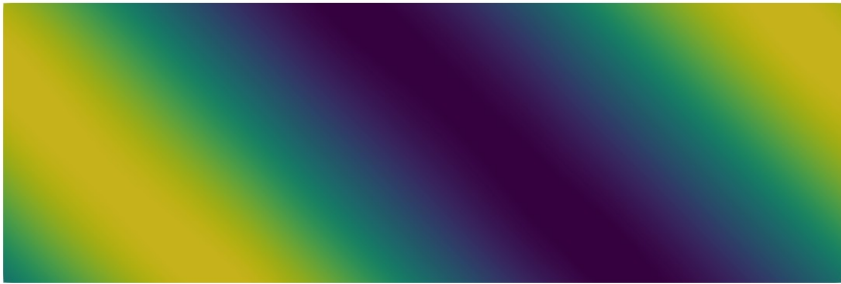
p4est Mesh Views



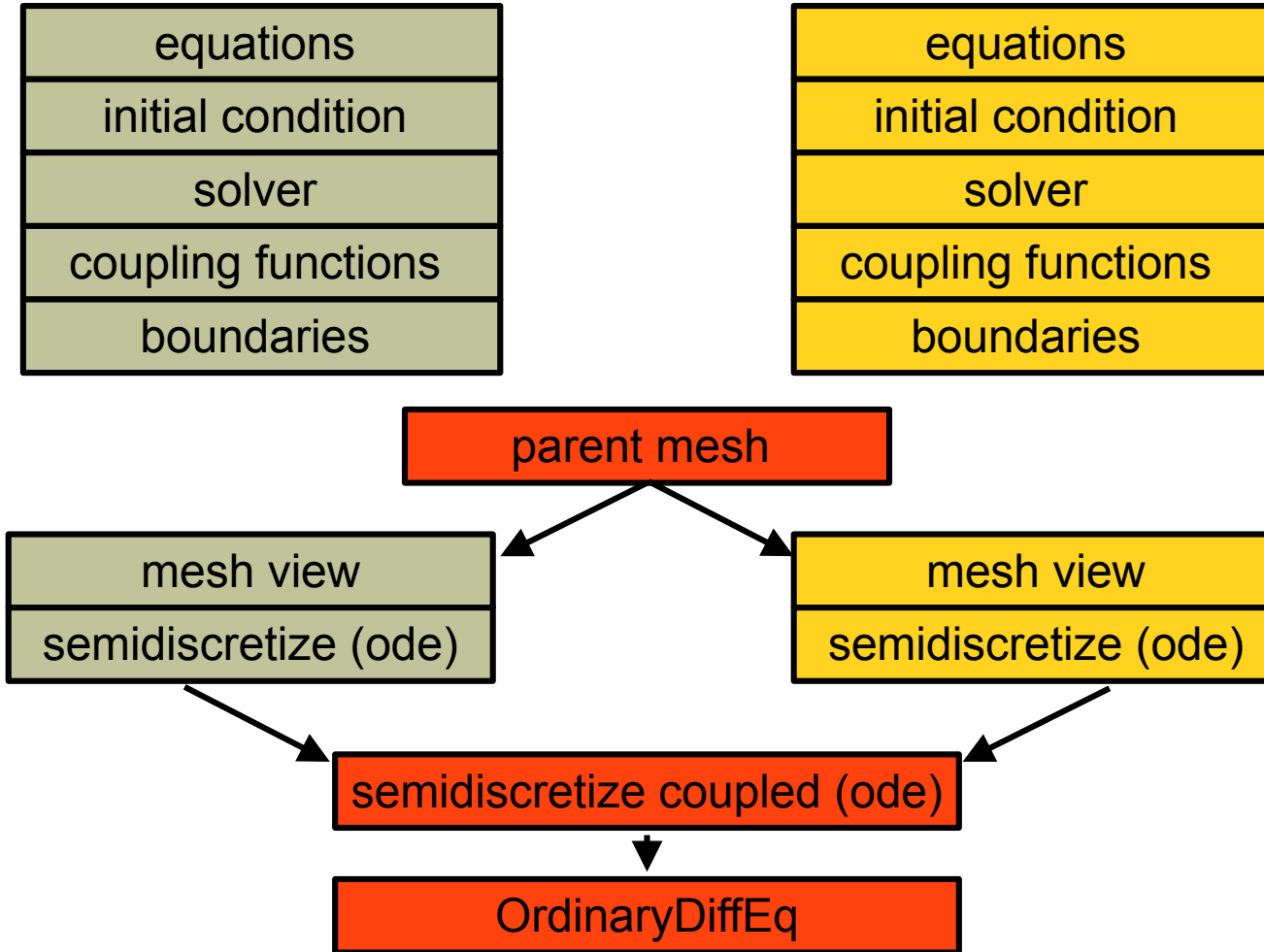
➡ p4est mesh views in Trixi.jl

➡ arbitrary topology

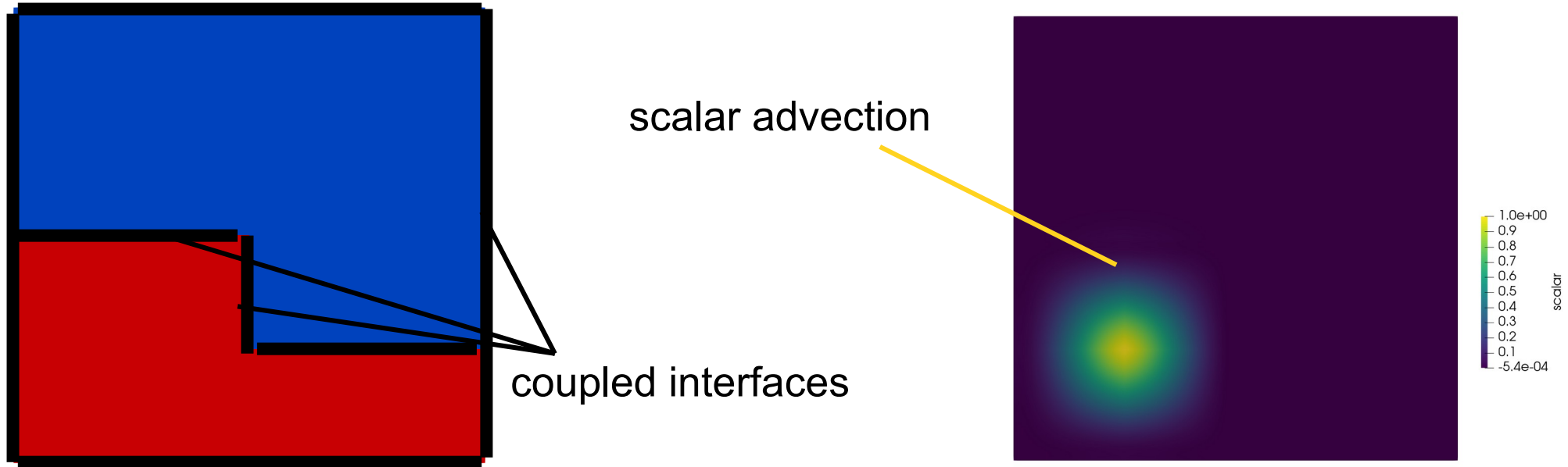
➡ views on smallest (cell) scale



Work Flow Coupling

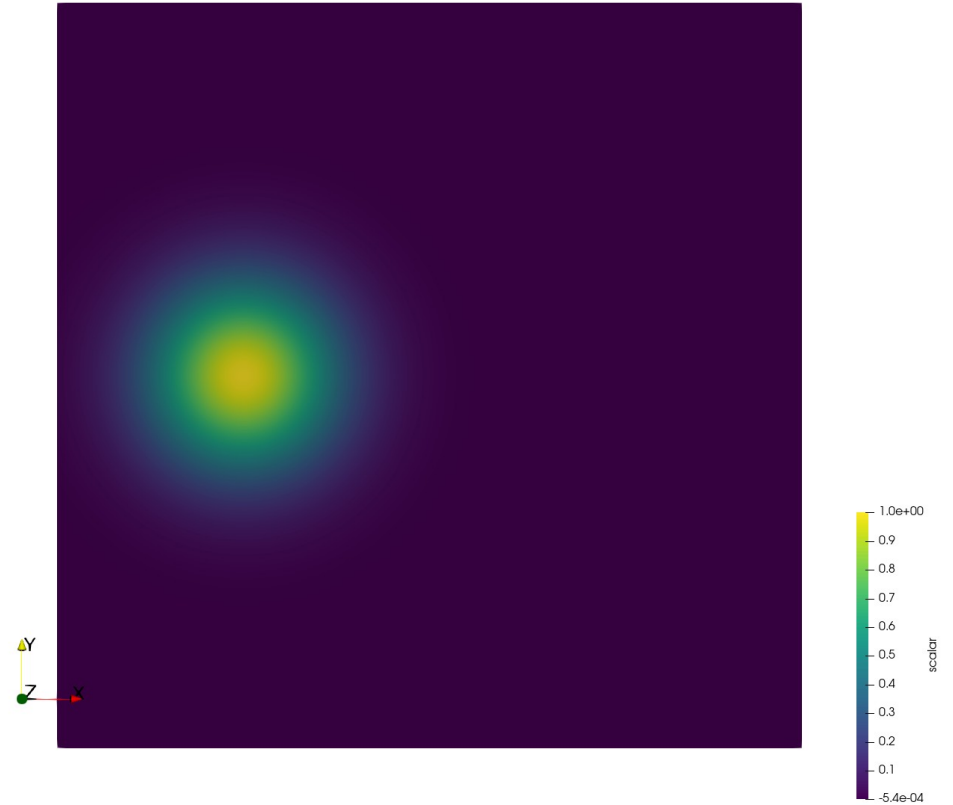
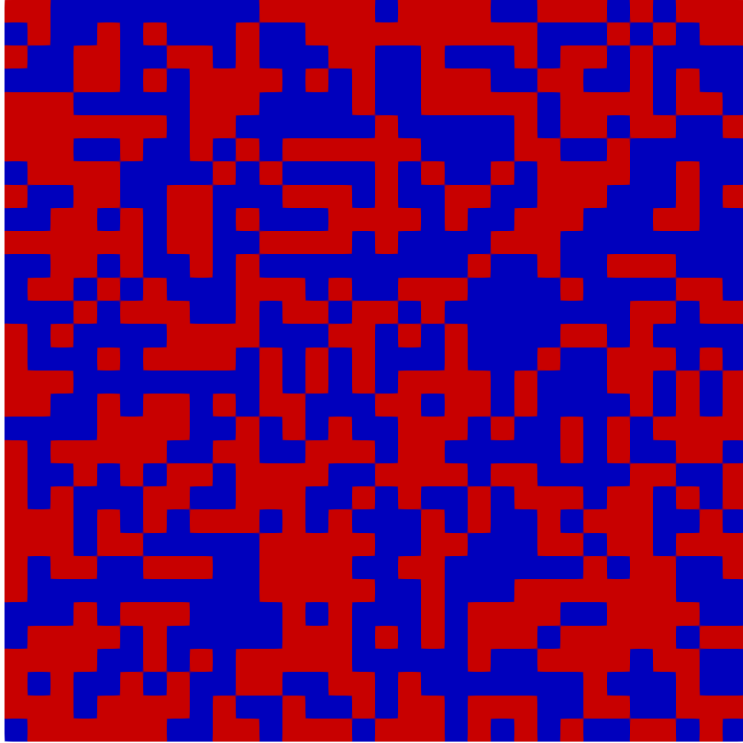


Linear Advection



$$\partial_t u + a_x \partial_x u + a_y \partial_y u = 0 \quad (a_x, a_y) = (0.05, 0.02)$$

Linear Advection



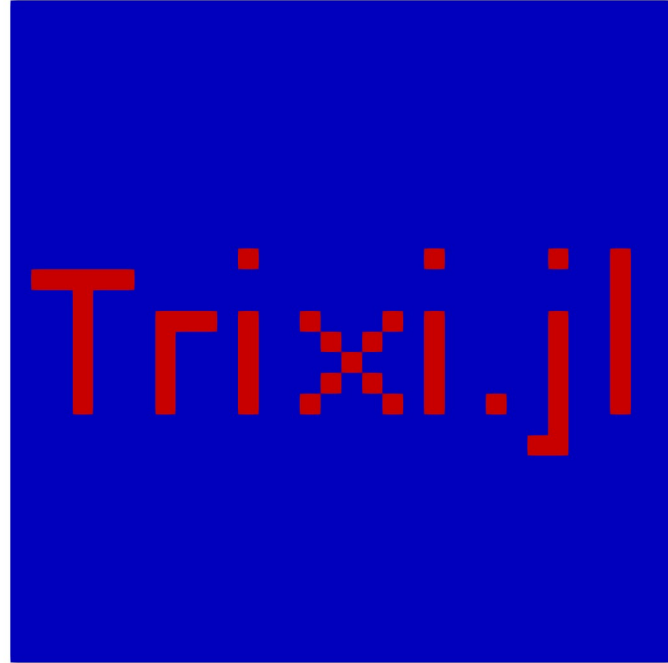
Linear Advection

BMP file:

Trixi.jl

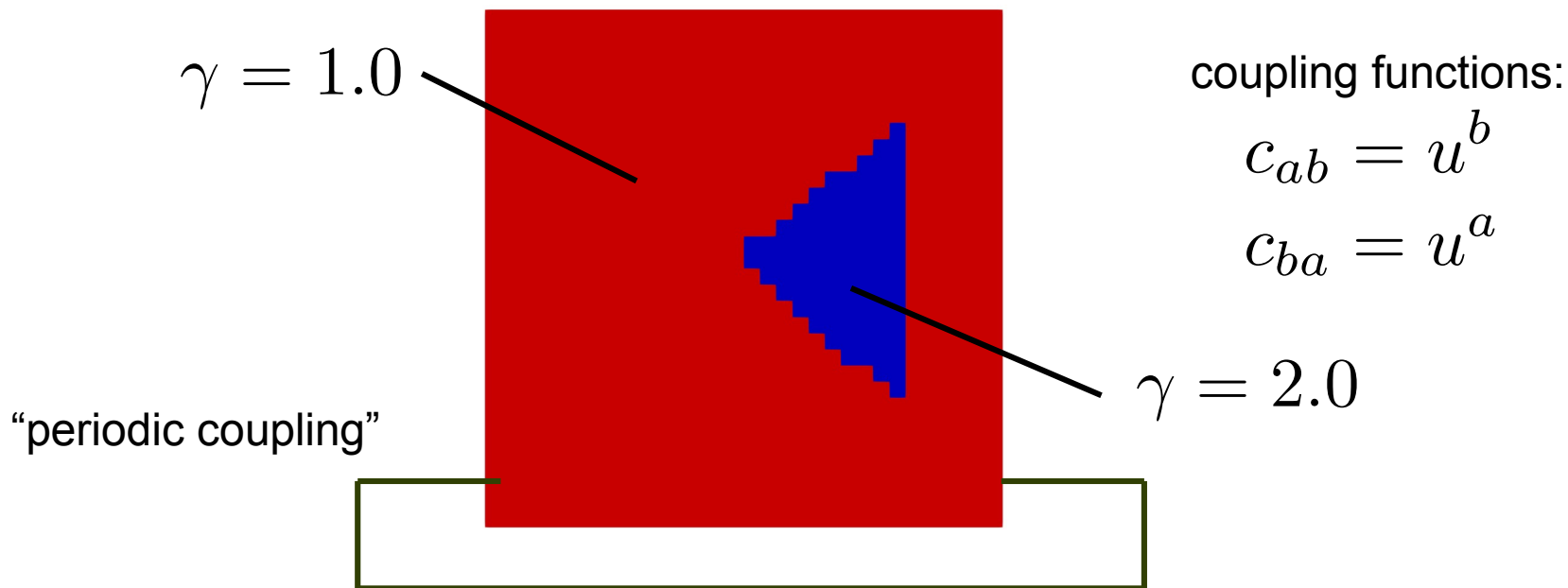


p4est domains:

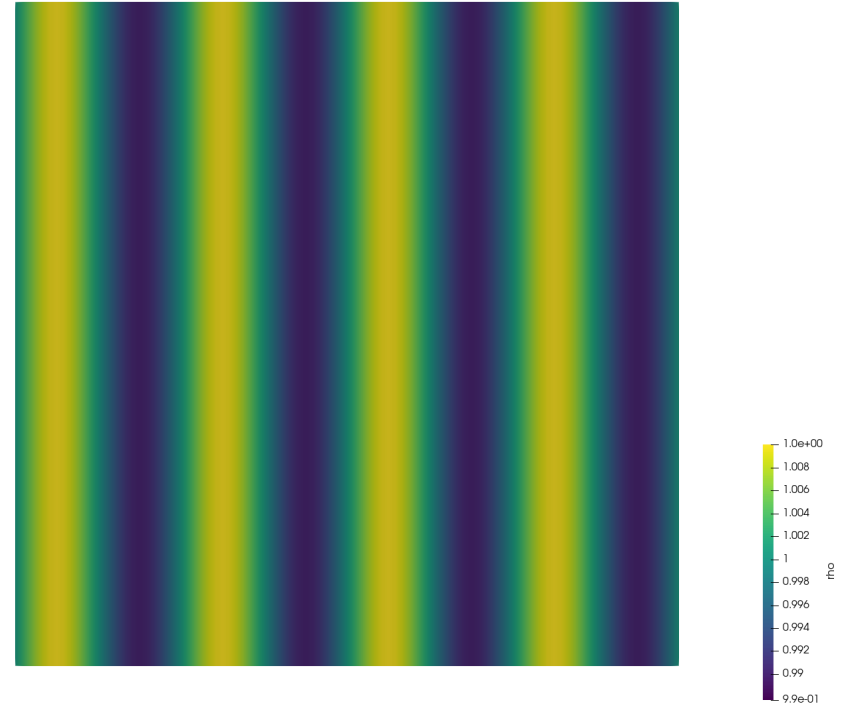
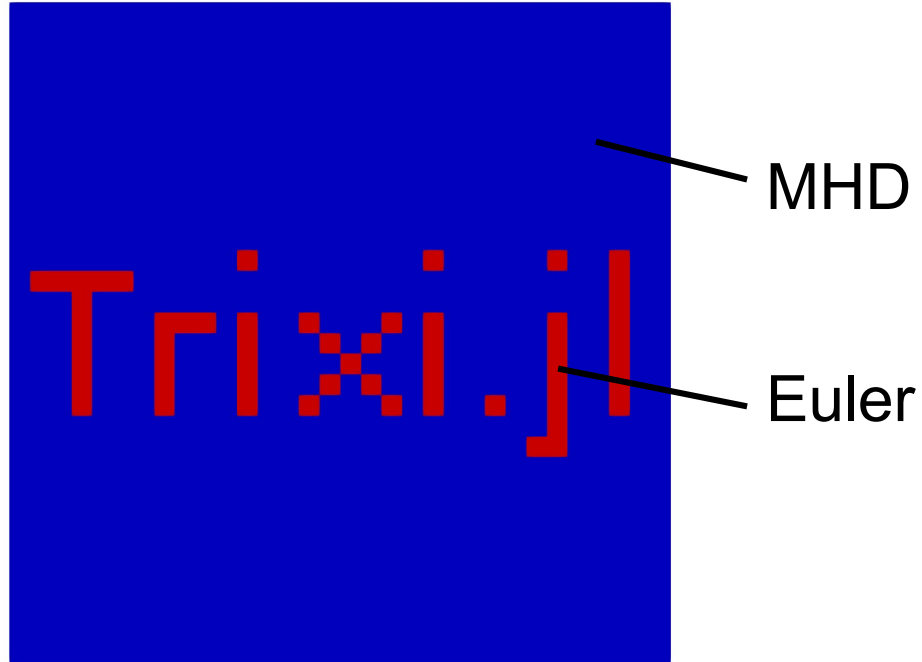


Isothermal-Polytropic

$$\partial t \begin{pmatrix} \rho \\ \rho v_1 \\ \rho v_2 \end{pmatrix} + \partial x \begin{pmatrix} \rho v_1 \\ \rho v_1^2 + \rho^\gamma \\ \rho v_1 v_2 \end{pmatrix} + \partial y \begin{pmatrix} \rho v_2 \\ \rho v_1 v_2 \\ \rho v_2^2 + \rho^\gamma \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$



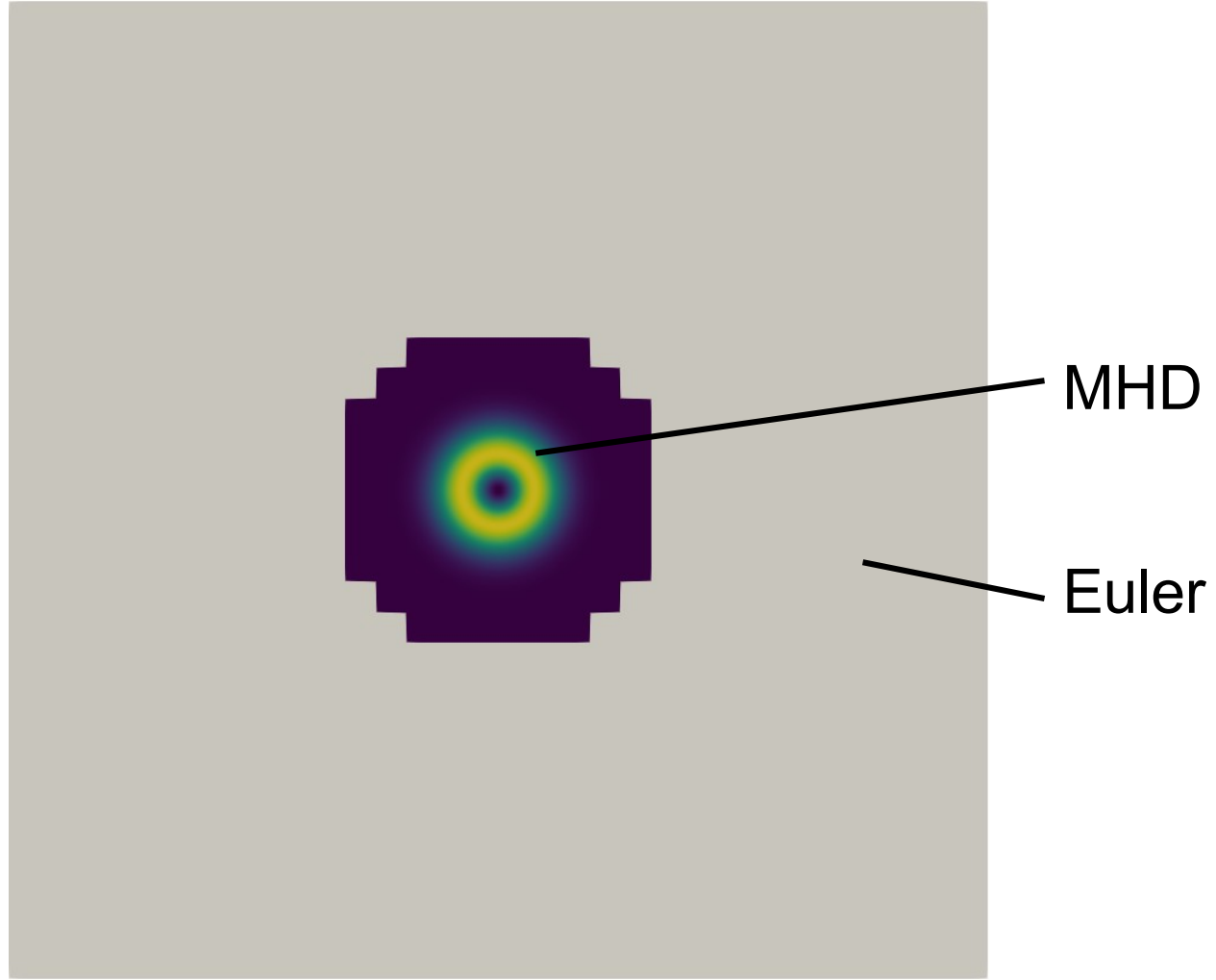
MHD-Euler



Adaptive Model Selection

1. Generate the new grid (mesh views).
2. Write new u-solution vectors
3. Generate new ODE for OrdinaryDiffEq (integrator).
4. Reinitialize ODE integrator with new problem and new solution vector.

MHD-Euler AMS



Conclusion

- ➡ Free domain definitions.
- ➡ Import meshes from an image.
- ➡ Coupled p4est simulations.
- ➡ Non-simply connected meshes in p4est.
- ➡ Adaptive model selection with arbitrary criteria.