Anisotropic and pressure-robust discretization of incompressible flows

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For some time, the class of pressure-robust discretizations for incompressible flows has sparked increased interest. They produce velocity approximations that are independent of how well the pressure can be approximated, and are highly advantageous in low viscosity regimes. While classical methods like the family of Taylor–Hood finite elements show a locking phenomenon induced by the viscosity parameter of the fluid, meaning that the error of the discrete velocity solution scales with the inverse of the viscosity, pressure-robust methods do not have this problem.

Incompressible flows tend to form layer structures, e.g., near walls, and exhibit singular solutions near re-entrant edges of the domain. These two effects cause additional difficulties for discretization approaches that can be addressed by anisotropic mesh grading, which uses highly stretched elements in boundary layer regions or near the re-entrant edges. A drawback with regard to the use of anisotropic grading is that proofs are available for only a few methods.

The talk focuses on the pressure-robust variants of the Crouzeix–Raviart and Bernardi–Raugel methods and their performance in the context of anisotropic meshes. Numerical examples are presented that support the results from the analysis.

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