

PRESSURE-ROBUST HIGH-ORDER FINITE ELEMENTS FOR INCOMPRESSIBLE FLOW

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ABSTRACT

Pressure-robust finite element methods have emerged as a powerful class of discretizations for incompressible flow problems. In recent years, a variety of such methods have been developed and analyzed, many of them being high-order. Their defining feature is that the velocity error is independent of the pressure, making them particularly effective in situations where the pressure exhibits low regularity. This structure-preserving property is especially important for time-dependent problems, where it is related to long-time stability and allows for viscosity-robust error estimates. Moreover, in coupled systems involving nonlinear terms that generate gradient fields, pressure-robust methods prevent spurious influences of these gradients on the discrete velocity, providing a significant advantage over standard discretizations.

This minisymposium brings together recent advances in the numerical analysis of pressure-robust finite element methods, including H^1 -conforming exactly divergence-free finite elements, $H(\text{div})$ -conforming methods, and reconstruction operator approaches. We will discuss their convergence, and conservation properties, as well as their computational costs and implementation aspects. By comparing different techniques, the minisymposium aims to provide a clearer understanding of the trade-offs between accuracy and robustness, and to identify the regimes and applications in which pressure-robust methods offer the greatest benefits. Ultimately, the goal is to facilitate their transfer to more advanced coupled fluid models and to challenging real-world applications.

SPEAKERS

1. Lorenzo Beirão da Veiga (University of Milan): A pressure-robust ALE space-time DG method for incompressible fluids on moving domains.
2. Franziska Eickmann (Technical University of Darmstadt): Pressure-robust estimates for the Scott-Vogelius finite element and iterated penalty method with inhomogeneous boundary conditions.
3. Martin Kronbichler (Ruhr University Bochum): On pressure robustness of Raviart–Thomas finite elements with high-order splitting methods.
4. Philip Lederer (University of Hamburg): Pressure-Robustness by commuting interpolation operators for Stokes Discretizations with continuous pressures.
5. Michael Neilan (University of Pittsburgh): Scott–Vogelius finite element methods for the surface Stokes problem.
6. Constanze Neusch (University of Hamburg): Gradient-robustness in the context of optimization.
7. Sara Zahedi (KTH Royal Institute of Technology): A pressure-robust Cut-FEM.
8. Pietro Zanotti (University of Milan): On the notions of robustness in linear elasticity.