Pressure-robustness in the context of the weakly compressible Navier–Stokes equations

Christian Merdon[1] Alexander Linke[2] Philip Lederer[3]

Pressure-robustness is an important property of a numerical scheme for accurate discretizations of the incompressible Navier–Stokes equations as it ensure the correct accounting of irrotational forces into the pressure gradient. For weakly compressible low Mach number flows the divergence-free part of the velocity is still large and is not affected by gradient forces. The talk connects pressure-robust discretizations for this divergence-free part with the well-balanced property for certain states like an atmosphere at rest where the pressure gradient balances the gravitational force.

Two families of methods that have this property are discussed. One employs a classical finite element method with an Hdiv-conforming interpolation in the right-hand side, the second directly employs Hdiv-conforming DG spaces. Together with a proper upwinding in the continuity equation at least their lowest order incarnations ensure density constraints and allow to show convergence on general shape-regular meshes. Numerical examples investigate convergence rates and illustrate the higher accuracy in well-balanced situations.

References:

[1] https://arxiv.org/abs/2311.06098

[1]Weierstrass Institute for Applied Analysis and Stochastics, Berlin
Christian.Merdon@wias-berlin.de

[2]University of Kaiserslautern-Landau
alexander.linke@rptu.de

[3]University of Twente
p.l.lederer@utwente.nl