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A Hybrid High-Order discretisation of the Brinkman problem robust in the Darcy and Stokes limits[☆]

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Abstract

In this work, we develop and analyse a novel Hybrid High-Order discretisation of the Brinkman problem. The method hinges on hybrid discrete velocity unknowns at faces and elements and on discontinuous pressures. Based on the discrete unknowns, we reconstruct inside each element a Stokes velocity one degree higher than face unknowns, and a Darcy velocity in the Raviart–Thomas–Nédélec space. These reconstructed velocities are respectively used to formulate the discrete versions of the Stokes and Darcy terms in the momentum equation, along with suitably designed penalty contributions. The proposed construction is tailored to yield optimal error estimates that are robust throughout the entire spectrum of local (Stokes- or Darcy-dominated) regimes, as identified by a dimensionless number which can be interpreted as a friction coefficient. The singular limit corresponding to the Darcy equation is also fully supported by the method. Numerical examples corroborate the theoretical results. This paper also contains two contributions whose interest goes beyond the specific method and application treated in this work: an investigation of the dependence of the constant in the second Korn inequality on star-shaped domains and its application to the study of the approximation properties of the strain projector in general Sobolev seminorms.

Keywords: Brinkman, Darcy, Stokes, Hybrid High-Order methods, Korn inequality, strain projector
2010 MSC: 65N30, 65N08, 76S05, 76D07

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