Discontinuous Galerkin Methods for the Variational Inequality Problems in Incompressible Flows

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In this work, discontinuous Galerkin methods are introduced and analyzed to solve a variational inequality from the hydrodynamics equations with a nonlinear slip boundary condition of friction type. Existence, uniqueness and stability of numerical solutions are shown for the discontinuous Galerkin methods. Error estimates are derived for the velocity in a broken H^1-norm and for the pressure in an L^2-norm, with the optimal convergence order when linear elements for the velocity and piecewise constants for the pressure are used. Numerical results are reported to demonstrate the theoretically predicted convergence orders, as well as the capability in capturing the discontinuity, the ability in handling the shear layers, and the application to the general polygonal mesh of the discontinuous Galerkin methods.