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Numerical methods for the Stokes and Navier-Stokes equations driven by threshold slip boundary conditions

Jules Djoko* Jonas Koko†

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Abstract

In this article, we discuss the numerical solution of the Stokes and Navier-Stokes equations completed by nonlinear slip boundary conditions of friction type in two and three dimensions. To solve the Stokes system, we first reduce the related variational inequality into a saddle point-point problem for a well chosen augmented Lagrangian. To solve this saddle point problem we suggest an alternating direction method of multiplier together with finite element approximations. The solution of the Navier Stokes system combines finite element approximations, time discretization by operator splitting and augmented Lagrangian method. Numerical experiment results for two and three dimensional flow confirm the interest of these approaches.

Keywords. nonlinear slip boundary condition, Stokes equations, Navier-Stokes equations, variational inequality, augmented Lagrangian, alternating direction method of multipliers, Marchuk-Yanenko's scheme, 3d-simulations.

1 Introduction

Numerical solutions for variational inequalities have been examined by many researchers, see for example, [22, 27, 28, 36, 47]. Roughly speaking, there are two main approaches to solve variational inequalities: the direct treatment of the inequality by making use of minimization techniques, and the transformation of the variational inequality into a variational equation by regularization or by introducing a "multiplier". It should be acknowledged

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