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A Nitsche method for fluid flow with dynamic and set-valued boundary conditions

Pablo Alexei Gazca Orozco

Charles University Prague
e-mail: gazca@karlin.mff.cuni.cz
ORCID: 0000-0001-9859-4238

Franz Gmeineder

University of Konstanz
e-mail: franz.gmeineder@uni-konstanz.de
ORCID: 0000-0002-2475-9201

Erika Maringová-Kokavcová

Institute of Science and Technology Austria
e-mail: erika.kokavcova@ist.ac.at
ORCID: 0000-0001-5478-9359

Tabea Tscherpel

TU Darmstadt
e-mail: tscherpel@mathematik.tu-darmstadt.de
ORCID: 0000-0002-5899-1279

Abstract. The classical no-slip (or homogeneous Dirichlet) boundary condition for fluid flow is not appropriate in many situations, as many fluids will often slip at solid walls. In this work we propose a theoretical framework that is able to capture a wide variety of slip models, including linear (Navier) slip, non-linear (and possibly non-smooth) slip described by monotone graphs, non-monotone slip, and dynamic (time-dependent) slip. A finite element scheme is proposed, in which the non-penetrability condition at the wall is enforced with a Nitsche formulation. One of the key tools in the convergence proof is an inhomogeneous Korn inequality that includes a normal trace term. Numerical experiments implemented in firedrake will also be presented. The talk is based on the recent work [1].

Keywords: slip boundary conditions; incompressible fluids; finite element method; Nitsche formulation; Korn inequality.

References

[1] **P.A. Gazca-Orozco, F. Gmeineder, E. Maringová-Kokavcová, T. Tscherpel.** A Nitsche method for incompressible fluids with general dynamic boundary conditions. *ArXiv Preprint:2502.09550*, 2025 (submitted).