Navier-Stokes equations with Navier boundary condition and behavior with respect to the slip length

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SUMMARY

Consider the dynamics of a viscous incompressible fluid given by non-stationary Navier-Stokes equation with slip boundary condition in a bounded domain

$$\begin{cases} \dfrac{\partial \boldsymbol{u}}{\partial t} - \Delta \boldsymbol{u} + (\boldsymbol{u} \cdot \nabla)\boldsymbol{u} + \nabla \pi = \boldsymbol{0}, \quad \text{div } \boldsymbol{u} = 0 & \text{in } \Omega \times (0, T); \\ \boldsymbol{u} \cdot \boldsymbol{n} = 0, \quad 2[(\mathbb{D}\boldsymbol{u})\boldsymbol{n}]_{\boldsymbol{\tau}} + \alpha \boldsymbol{u}_{\boldsymbol{\tau}} = \boldsymbol{0} & \text{on } \Gamma \times (0, T); \\ \boldsymbol{u}(0) = \boldsymbol{u}_0 & \text{in } \Omega. \end{cases} \tag{1}$$

Here Ω is a bounded domain in $\mathbb{R}^3$ with boundary Γ. The initial velocity $\boldsymbol{u}_0$ and the (scalar) friction coefficient α are given functions; The unknowns are $\boldsymbol{u}$ and π which describe respectively the velocity and the pressure of the fluid flow.

The boundary condition in (1) was introduced by H. Navier which is in recent years widely studied because of its significance in different real world model for simulation of flows and fluid-solid interaction problems.

I will discuss the well-posedness of the above system imposing minimal regularity on α. Weak and strong solutions of the associated Stokes operator and the resolvent estimate, uniform in the friction coefficient α, is deduced which enables us to obtain bounds on the solution of (1) independent of α. Finally we study the behaviour of the solution of (1) with respect to the friction coefficient, in particular what happens if α goes to ∞.