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# A deposition model coupling Stokes' and Darcy's equations with nonlinear deposition

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## Abstract

In this work we investigate a filtration process whereby particulate is deposited in the flow domain, causing the porosity of the region to decrease. The fluid flow is modeled as a coupled Stokes-Darcy flow problem and the deposition (in the Darcy domain) is modeled using a nonlinear equation for the porosity. Existence and uniqueness of a solution to the governing equations is established. Additionally, the nonnegativity and boundedness of the porosity is shown. A finite element approximation scheme that preserves the nonnegativity and boundedness of the porosity is investigated. Accompanying numerical experiments support the analytical findings.

**Key words.** Stokes equation, Darcy equation, filtration

**AMS Mathematics subject classifications.** 76D07, 35M10, 35Q35, 65M60, 65M55

## 1 Introduction

Applications of filtration abound in our everyday lives. From the routine activities such as: the preparation of espresso coffee in the morning [13], the water we drink from the faucet [29], and the car we drive to work [26]. To the less obvious but not less important such as: The absorption of nutrients in the small intestine [22], the cleansing of blood in the kidneys [21], and the prevention of postoperative infections [23]. All these phenomena rely on the separation of some solid from a fluid by means of a medium that is permeable to the fluid but (mostly) impermeable to the solid.

In this work we investigate a filtration process whereby particulate is deposited in the flow domain, causing the porosity of the region to decrease. The fluid flow is modeled as a coupled Stokes-Darcy flow problem and the deposition (in the Darcy domain) is modeled using a nonlinear equation for the porosity. (See Figure 1.) The model considered in this paper extends the work presented in [11] where the analysis was restricted to the filtration domain.

The addition of the upstream flow domain introduces into the model a different set of flow equations which must be suitably coupled across the interface ( $\Gamma$ ) between the two subdomains. The coupling equations, given in (2.6) represent the conservation of mass across  $\Gamma$  (see (2.6a)), the conservation of the normal component of stress across  $\Gamma$  (see (2.6b)), and an equation (the Beavers-Joseph-Saffman condition (2.6c)) for the tangential component of the stress vector on the Stokes domain.

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