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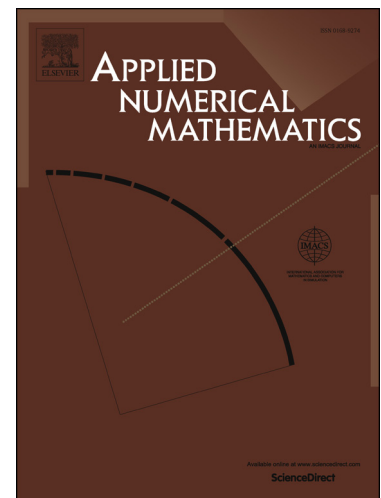
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# First order system least squares pseudo-spectral method for Stokes-Darcy equations

Peyman Hessari,<sup>\*</sup> Byeong-Chun Shin<sup>†</sup>

## Abstract

The subject of this paper is to investigate the first order system least squares Legendre and Chebyshev pseudo-spectral methods for coupled Stokes-Darcy equations. By introducing strain tensor as a new variable, Stokes-Darcy equations recast into a system of first order differential equations. The least squares functional is defined by summing up the weighted  $L^2$ -norm of residuals of the first order system for coupled Stokes-Darcy equations. To treat Beavers-Joseph-Saffman interface conditions, the weighted  $L^2$ -norm of these conditions are also added to the least squares functional. Continuous and discrete homogeneous functionals are shown to be equivalent to the combination of weighted  $H(\text{div})$  and  $H^1$ -norm for Stokes-Darcy equations. The spectral convergence for the Legendre and Chebyshev methods are derived. To demonstrate this analysis, numerical experiments are also presented.

**Keywords:** Coupled Stokes-Darcy equations, Legendre and Chebyshev spectral approximation, First order system least squares method, Beavers-Joseph-Saffman interface conditions.

## 1 Introduction

Let  $\Omega$  be an open bounded domain divided into two sub-domains  $\Omega_S$  and  $\Omega_D$  with the curve  $\Gamma$ , such that  $\overline{\Omega} = \overline{\Omega_S} \cup \overline{\Omega_D} \cup \Gamma$ . Here,  $\Gamma$  is referred to as *interface*. The boundary of  $\Omega$  is denoted by  $\partial\Omega$  and  $\partial\Omega_S = \overline{\Omega_S} \cap \partial\Omega$ ,  $\partial\Omega_D = \overline{\Omega_D} \cap \partial\Omega$ , (see Figure 1). Assume that flow in  $\Omega_S$  is governed by the Stokes equations

$$(1) \quad \begin{cases} -\nabla \cdot \mathbf{T} = \mathbf{f}, & \text{in } \Omega_S, \\ \nabla \cdot \mathbf{u} = 0, & \text{in } \Omega_S, \end{cases}$$

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