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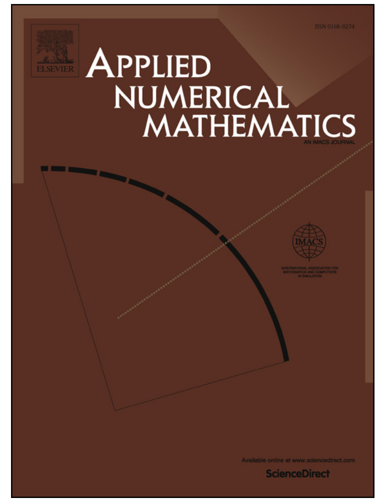

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First order system least squares pseudo-spectral method for Stokes-Darcy equations

Peyman Hessari,[*] *Byeong-Chun Shin*[†]

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 Ω be an open bounded domain divided into two sub-domains Ω_S and Ω_D with the curve Γ, such that $\overline{\Omega} = \overline{\Omega_S} \cup \overline{\Omega_D} \cup \Gamma$. Here, Γ is referred to as *interface*. The boundary of Ω 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 Ω_S is governed by the Stokes equations

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

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