A numerical study for the MHD Jeffery-Hamel problem based on orthogonal Bernstein polynomials

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Abstract

In this investigation, a collocation method based on orthogonal Bernstein polynomials for solving MHD Jeffery-Hamel problem is introduced. The validity of the proposed method is ascertained by comparing our results with fourth-order Runge-Kutta method (RK4) results.

Keywords: Orthogonal Bernstein polynomials, Jeffery-Hamel flows, Fluid mechanics
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1 Introduction

The problem of an incompressible, viscous fluid between nonparallel walls, commonly known as the Jeffery-Hamel flow, is an example of one of the most applicable type of flows in fluid mechanics [1]. Consequently, this problem has been well studied in literature, see for example, [2, 3].The classical Jeffery-Hamel problem was extended in [4] to include the effects of an external magnetic field on an electrically conducting fluid. In this study, we are going to introduce and implement a collocation method based on orthogonal Bernstein polynomials [5] to find the approximate solution of the MHD Jeffery-Hamel problem.

2 Mathematical formulation

Consider the steady two-dimensional flow of an incompressible conducting viscous fluid from a source or sink at the intersection between two rigid plane walls, where the angle between them is 2α as shown in Fig. 1. We assume that the velocity is only along the radial direction and depends on r and θ,$V(u(r,\theta),0)$ [1]. Using continuity and the Navier-Stokes equations in polar coordinates,

$$\frac{\rho\partial}{r\partial r}(ru(r,\theta)) = 0, \tag{1}$$

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