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Double diffusive convection in a rotating anisotropic porous layer saturated with viscoelastic fluid

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ABSTRACT

The onset of double diffusive convection in a binary viscoelastic fluid-saturated anisotropic rotating porous layer is studied using a linear and a weakly non-linear stability analyses. The modified Darcy law for the viscoelastic fluid of the Oldroyd type is used to model the momentum equation. The onset criterion for stationary and oscillatory convection is derived analytically. There is a competition between the processes of thermal, solute diffusions and viscoelasticity that causes the convection to set in through oscillatory rather than stationary. The effect of anisotropy parameters, Vadasz number, relaxation and retardation parameters on the stability of the system is investigated. It is found that contrary to their usual influence on the onset of convection in the absence of rotation, the thermal anisotropy parameter and Vadasz number show contrasting effect on the onset criterion. The non-linear theory based on the truncated representation of Fourier series method is used to find the transient heat and mass transfer. The effect of various parameters on heat and mass transfer is also considered.
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1. Introduction

The problem of double diffusive convection in fluid and porous media has attracted considerable interest during the last few decades because of its wide range of applications, from the solidification of binary mixtures to the migration of solutes in water-saturated soils. The other important examples include geophysical systems, electro-chemistry, the migration of moisture through air contained in fibrous insulation. A comprehensive review of the literature concerning natural convection in fluid-saturated porous media may be found in the books by Ingham and Pop [1,2], Nield and Bejan [3], Vafai [4,5] and Vadasz [6].

The study of double diffusive convection in a rotating porous media is motivated both theoretically and by its practical applications in engineering. Some of the important areas of applications in engineering include the food and chemical process, solidification and centrifugal casting of metals, rotating machinery, petroleum industry, biomechanics and geophysical problems. There are only few studies available on double diffusive convection in the presence of rotation. Chakrabarti and Gupta [7] have analyzed the non-linear thermohaline convection in a rotating porous medium. The effect of rotation on linear and non-linear double diffusive convection in a sparsely packed porous medium was studied by Rudraiah et al. [8]. The effect of anisotropy of the porous medium on the onset of double diffusive convection in a rotating porous medium has been studied by Patil et al. [9]. The Lyapunov direct method is applied to study the non-linear conditional stability problem of a rotating doubly diffusive convection in a sparsely packed porous layer by Guo and Kaloni [10]. The non-linear stability of the conduction–diffusion solution of a fluid mixture heated and salted from below and saturating a porous medium in the presence of rotation is studied by Lombardo and Mulone [11] using Lyapunov direct method. Recently, Malashetty and Heera [12] studied linear and non-linear double diffusive convection in rotating porous layer using a thermal non-equilibrium model.

Interest in viscoelastic flows through porous media has grown considerably, due to the demands of such diverse areas as biorheology, geophysics, chemical and petroleum industries. The published work on thermal convection of viscoelastic fluids in porous media is fairly limited. Rudraiah et al. [13,14] have studied the stability of viscoelastic fluid-saturated porous layer using Darcy and Brinkman models. A theoretical analysis of thermal instability in a porous layer saturated with viscoelastic fluid is carried out by Kim et al. [15]. They found that the overstability is a preferred mode for a certain range of parameters and the onset of convection has the form of a supercritical and stable bifurcation independent of the values of the elastic parameters. Yoon

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