Effects of thermorheological viscosity on Rayleigh-Benard magnetoconvection on Newtonian liquid-Linear Stability Analysis

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Abstract

The Rayleigh-Ritz method is employed in the study for understanding variable thermorheological effects of viscosity for Rayleigh-Benard magnetoconvection. One of the similarity transformation normal mode technique is employed to the governing equations into ordinary differential equations. Single term Rayleigh Ritz technique is used to understand the stability of the system. The flow parameters like Rayleigh number (Ra), variable viscosity parameter(V), Chandrashekar number(Q) are also examined in the study. Different boundary combinations viz free-free, free-adiabatic, adiabatic-free, adiabatic-adiabatic are employed to understand the stability of the system. From the analysis, it is noted that critical Rayleigh number (Rc) is maximum for the boundary condition RI-RI and is minimum for FA-FI and FI-FI for Q=1, V=1. The results have possible applications in astrophysics, geophysics, industries, medical and environmental sciences.

Keywords: Rayleigh-Benard convection, exponential shear viscosity, thermorheological effects.

1. INTRODUCTION & OBJECTIVE

The buoyancy-driven Bénard convection in electrically conducting Newtonian liquids in the presence of an applied magnetic field is caused by either buoyancy or surface tension. The study of magnetoconvection is now very important in many branches of engineering and science. It has a wide and variety of applications in the field of astrophysics. Early research interest in magnetoconvection was primarily motivated by geophysical and astrophysical problems and later the use of magnetic fields for clinical purposes in the detection and treatment of certain diseases. Some important works, such as Chandrasekhar (1961) and Danielson (1961), are all based on magnetoconvection. These works are useful for studying penumbral convections and sunspots.

Recently, Ramachandramurthy et al. (2011) investigated the effect of thermorheological parameters on the onset of Rayleigh-Benard and Benard-Marangoni magnetoconvection by considering the Neilds model (1996). They employed the higher-order Rayleigh-Ritz method to solve the eigenvalue of the problem. The current research aims at a linear stability theory of Rayleigh-Benard magneto convection in electrically conducting Newtonian fluids in temperature-dependent variable viscosity by considering the exponential model (Torrance and Turcotte (1971), Aruna et al. (2022, 2023)). In this problem, we considered different boundary combinations in order to analyze the stability of the system. The single-term Rayleigh-Ritz method is employed to determine the eigenvalue of the problems. This problem has possible applications in the fields of astrophysics and geophysics.

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

In the paper, we study the effects of variable viscosity (exponential form) and magnetic field on Rayleigh-Bénard convection under various boundary combinations. It is found that the effect of increasing the thermorheological parameter is to advance the onset of convection. But the effect of increasing Chandrasekhar number is to inhibit the same (stabilize the system). The following table presents the critical Rayleigh and wave number for the different values of Chandrasekhar number and thermorheological parameter with different boundary combinations.

Boundary combination	$Q = 0,\ V = 0$		$Q = 1,\ V = 0$		Q = 0, V = 1		Q = 1, V = 1	
	Rc	Kc	Rc	Kc	Rc	Kc	Rc	Kc
RI-RI	1749.98	3.11652	2206.72	3.14501	1130.66	3.13066	1587.12	3.16883
RA-RI	947.44	2.05206	1365.26	2.11334	596.943	1.95684	1017.47	2.07148
RI-FI	1138.7	2.66977	1601.03	2.7885	739.394	2.56296	1205.79	2.75928
RA-FI	947.44	2.05206	1365.26	2.11334	596.943	1.95684	1017.47	2.07148
RI-FA	691.253	2.05206	996.091	2.11334	435.53	1.95684	742.35	2.07148
FI-FI	664.525	2.22697	1096.29	2.47829	428.518	2.20312	856.913	2.54986
FA-FI	664.525	2.22697	1096.29	2.47829	428.518	2.20312	856.913	2.54986

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