Weakly nonlinear stability of a Rayleigh-Bénard magnetoconvective system with sinusoidal and nonsinusoidal temperature modulations

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1. INTRODUCTION & OBJECTIVE

This paper examines the weakly nonlinear stability of a Rayleigh-Bénard magnetoconvective system of a Boussinesq electrically conducting Newtonian fluid under the imposition of sinusoidal and nonsinusoidal temperature gradients. In addition to a sinusoidal modulation, periodic nonsinusoidal temperature modulations of three distinct types - square wave, triangle wave, and sawtooth wave - are taken into consideration. A perturbative study about the system's threshold for the onset of convection is carried out to derive a nonautonomous cubic Ginzburg-Landau equation, whose solution yields the convective amplitude. For each of the four modulations, the time-series plot of the numerically evaluated Nusselt number is obtained, and its variation with changes in the system's input parameters - the Chandrasekhar number, the Prandtl number, and the magnetic Prandtl number, the amplitude of modulation and the frequency of modulation - is examined. The behavior of the time-averaged Nusselt number over a positive half-cycle with changes in the input parameters is examined, and the effects of the different types of modulations on heat transfer are compared.

2. HIGHLIGHTS AND RESULTS OF IMPORTANT POINTS

The effect of periodic temperature modulation on the onset of stationary convection in Rayleigh-Benard magnetoconvection is investigated for sine, square, triangular and sawtooth wave modulations. The effect of the Chandrasekhar number is to decrease the heat transfer, thereby confirming that the magnetic field tends to stabilize the system. The amplitude of time-periodic oscillations in the value of the Nusselt number is directly proportional to the amplitude of the temperature modulation, whereas increasing the frequency leads to decrease in its amplitude. While increase in the magnetic Prandtl number decreases the amplitude of the Nusselt number oscillations about the unmodulated value, an increase in the Prandtl number seems to slightly increase the amplitude. The results show that the amplitude of oscillations in the value of the Nusselt number is highest for square wave modulation and lowest for sawtooth wave modulation, with values for sine and triangular wave modulations falling in between.

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