Investigation of parallel rolls of electrically conducting fluid in a rotating magnetic system

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ABSTRACT

Nonlinear convection of electrically conducting fluid plane layer heating from below and rotating about the vertical axis in the presence of a magnetic field is studied theoretically using the Boussinesq approximation. Attention is focused on the above onset of stationary convection as the temperature difference applied across the plane layer is increased. This theoretical approach is carried out to study the parallel rolls, which are parallel to the magnetic field with free-free boundary conditions. By expanding the dependent variables in a series of orthogonal functions, and expanding the coefficients of these functions in power series of a parameter (ϵ), a solution has been obtained for the system of non-linear equations of cellular convection. The nonlinear problem is solved by using Fourier analysis of perturbations until the order of ϵ^8 to study the parallel rolls visualization. The numerical and graphical results are presented. The dependence of the Nusselt number on the Rayleigh number (*R*), the Ekman number (*E*) is examined. The transfer of heat by fluid flow is analyzed in the form of kinetic energy, potential energy, streamlines, isotherms, and heatlines. It has been observed that *E* stabilizes the system.

Keywords: Magnetohydrodynamics, Electrically conducting fluid, Nonlinear convection, Parallel rolls

METHOD OF SOLUTION

Following Kuo [1] the solution in a power series in the parameter ($\epsilon < 1$) is expanded as

ϵ^2= (R-R_{cs})/R. The solution of basic equations are written as f= $\epsilon f_1+\epsilon^2 f_2+ \epsilon^3 f_3+$

$\epsilon^4 f_4+$…….

CONCLUSIONS

In this problem, we demonstrated analytically the Rayleigh Benard system with the electrically conducting fluid rotating about the vertical axis in the presence of a uniform, horizontal and externally applied magnetic field. In the plane layer the heatlines, streamlines, and isotherms are extensively analyzed to demonstrate the heat flow of the Earth's liquid core. Rolls parallel to the magnetic field, at larger Ekman numbers (*E*). The heat transfer is primarily convection dominant for $R > R_{cs}$ due to the large amount of heat flow from the bottom. It is observed that the maximum value of the local Nusselt number increases as *R* increases. As *E* decreases the number of peaks of local Nusselt number increases. From Nusselt number results it is noted that the heat flux occurs more as *E* decreases. The total energy of the system increases as *E* decrease. Based on the heatline, streamlines and isotherms trajectories it has been decided, as decrease *E* the flow field gets more deformation and heat transfer occurs more due to the enhanced rotation.

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