Effects of cross-diffusion on the onset of double-diffusive magneto convection in a Voigt fluid layer

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ABSTRACT

The linear instability of double-diffusive magnetoconvection with cross-diffusion effects in a Voigt fluid layer is examined theoretically. The system behaves as a triply diffusive one with the additional diffusing component magnetic field. The condition for the onset of stationary and oscillatory convection is derived analytically. Under certain conditions, it is shown that (i) the magnetic field and bottom-heavy solute gradient destabilize the system which otherwise show a stabilizing effect on the system, (ii) a doubly diffusive conducting Voigt fluid layer can be destabilized in the presence of magnetic field and (ii) disconnected closed convex oscillatory neutral curves occur, indicating the requirement of three critical values of the thermal Rayleigh number to identify the linear instability criteria instead of the usual single value. The numerical results show that the cross-diffusion effects in displaying complex dynamical behavior on the system. The nature of linear instability characteristics for the presence and absence of cross-diffusion terms is found to be contradictory for the identical values of governing parameters. It is also observed that slight variations in the Kelvin-Voigt parameter, off-diagonal elements significantly alter the nature of convective instability. The effects of solute Rayleigh number, Chandrasekhar number, and the ratio of diffusivities on the system are presented graphically. The numerical results delineated under the limiting cases are shown to be in good agreement with those published previously.

Keywords: Heat and mass transfer, Magneto convection, Soret and Dufour effects, Voigt fluid.