Impact of couple stresses on convective stability in Navier-Stokes-Voigt fluid

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Abstract

This study investigates the impact of couple stresses on the convective stability of Navier-Stokes-Voigt fluid across various combinations of bounding surfaces (i.e. free-free, rigid-free, and rigid-rigid). Eigenvalue problems are derived through both nonlinear and linear analyses. For nonlinear stability analysis, the energy method is employed, whereas for linear instability analysis, normal mode analysis is utilized. Galerkin method is employed to compute the Rayleigh number. Both analyses produce identical Rayleigh numbers, indicating the absence of subcritical regions and implying global stability. The validation of principle of exchange of stabilities confirms that there are no oscillatory modes of convection. The presence of the couple stresses postpones the onset of convection. The observation also indicates that a fluid confined within rigid-rigid bounding surfaces exhibits higher thermal stability, making it particularly conducive for convection in Navier-Stokes-Voigt fluid.