Double diffusive convection in a micropolar fluid occupying enclosures with realistic boundaries

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1. INTRODUCTION & OBJECTIVE

The purpose of the study is to examine effect of double diffusive effect in Rayleigh-Bénard setup taking micropolar fluid occupying enclosures. Linear and non-linear stability analysis of the problem is carried out by deriving the Lorenz model considering Fourier-series representation. In this study, three different enclosure types — shallow (h < b), square (h = b), and tall (h > b) are examined, where h - height and b – breadth of the enclosure. According to the study, shallow enclosure is more stable than square and shallow enclosure. On the other hand, heat transport is more in tall enclosure. The mass transfer is more in shallow enclosure compared to other enclosures. Graphs are plotted to study and demonstrate the effects of micropolar fluid characteristics on Rayleigh-number and average Nusselt number and Sherwood number.

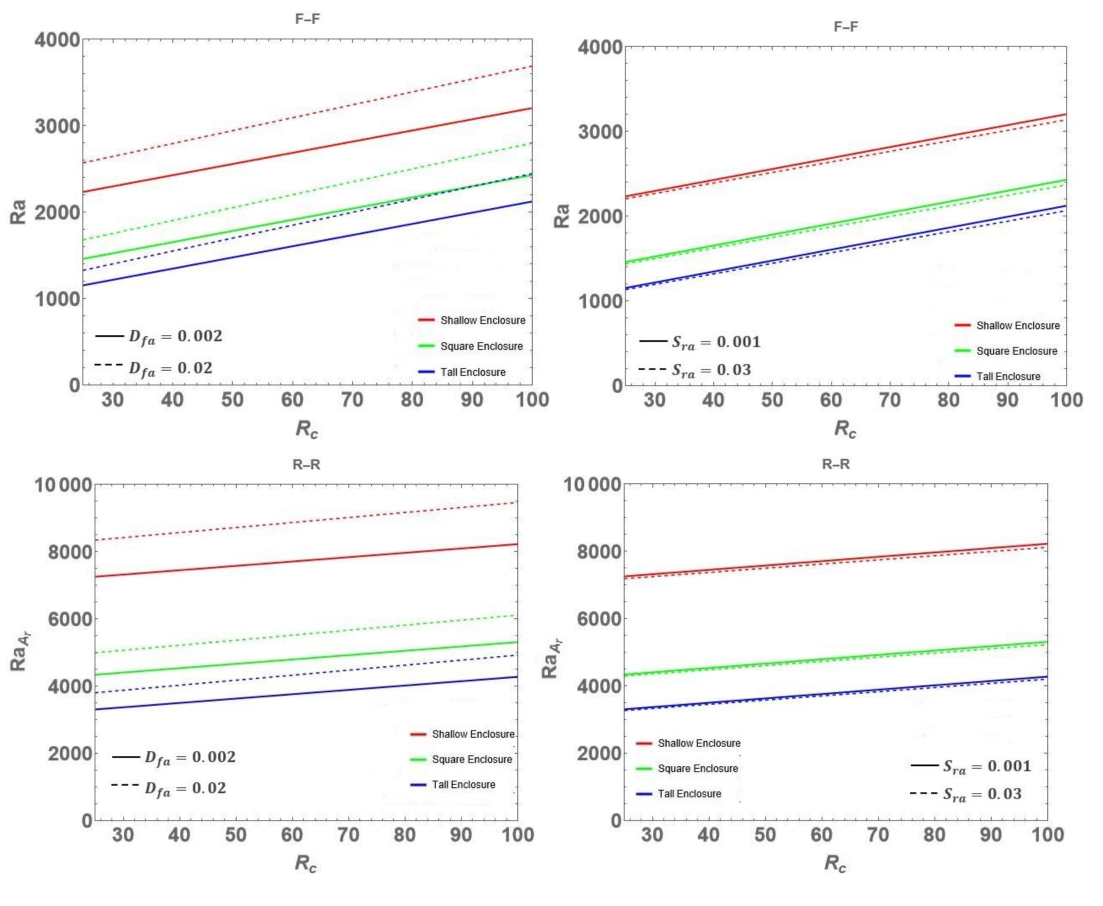
In the case of two-component convection (or thermosolutal convection) the fluid flow is generated by buoyancy effects. The presence of both temperature and concentration gradient promotes fluid flow in this system. On comparison with single-component fluid, these types of fluids have prominent applications in emerging technology. Due to the mixing of two-components having different diffusivity, it gives rise to two additional parameters namely Dufour and Soret parameter. The Soret effect is the chemical potential gradient that resulted from the temperature difference in the system and the Dufour effect is due to the dependence of the heat flux on concentration gradient term. The Soret effect and the Dufour effect are mutually opposing.

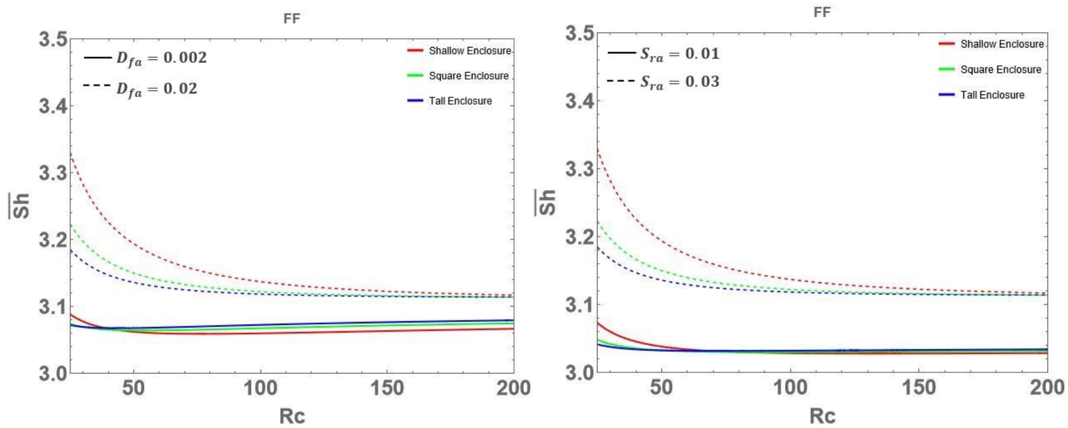
Enclosures are finite spaces that are bounded and filled with liquids or gases. Natural convection in enclosures has become one of the most active fields in current research due to several applications in the field of engineering. Rayleigh-Bénard convection in Newtonian liquids and Newtonian nano liquids occupying rectangular, square, and slender vertical enclosures was studied by Siddheshwar and Kanchana [1]. They employed the multiscale method to change the analytically intractable Lorenz model into a tractable Ginzburg-Landau equation, whose solution aids in quantifying unsteady heat transport. An analytical study of Rayleigh-Bénard convection within four different types of enclosures in a non-inertial frame of reference was carried out by Kanchana et al [2]. In this work, using the method of multi-scales, they have reduced the extended Lorentz-model to the Stuart-Landau equation. The other recent works on enclosures can be seen in [3], [4], [5], [6].

From the above survey of literature, it is noted that no study has been conducted to investigate Double diffusive convection in micropolar fluid occupying enclosure. Thus, the main objective of the present study is to investigate linear and non-linear analysis of double diffusive convection in a micropolar fluid occupying enclosures with realistic boundaries.

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

1. From Figures, it is evident that the value of Ra is higher in shallow enclosure compared to square and tall enclosure. In the case of tall enclosure, the advanced onset of convection make the system unstable. The onset of convection is delayed in shallow enclosure resulting in a stable system. The mass transfer is more in shallow enclosure compared to other enclosures.
2. The Free-Free (F-F) boundaries are comparatively less stable than Rigid-Rigid (R-R) boundaries.
3. The coupling parameter and micropolar heat conduction parameter stabilizes the system while on the other hand the couple stress parameter destabilizes the system.
4. The rate of heat transfer reduces with an increase in coupling parameter and micropolar heat conduction parameter. Whereas Nusselt number increases with increase in the couple stress parameter.
5. The Rayleigh number decreases with increase in Soret parameter. As Soret parameter increases, the mass flux enhances.





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