Unsupervised AI for Sustainable Heat Transfer using Nano-Enhanced Phase Change Materials

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Abstract

Background: This study explores the three-dimensional magnetohydrodynamic (MHD) flow of a nanofluid incorporating nano-encapsulated phase change materials (NEPCMs). The investigation highlights Hall and ion effects in buoyancy-driven flows with velocity and temperature slip conditions.

Purpose: The research aims to model and analyse the heat transfer characteristics and flow behaviour in an NEPCM-based MHD nanofluid system over a wedge, addressing the challenges posed by three-dimensional geometries and coupled physical effects.Uddin [2015] Yih [1999] Chamkha et al. [2003]

Methodology: The governing nonlinear partial differential equations are reduced to a system of nonlinear ordinary differential equations (ODEs) using similarity transformations, then these ODEs are solved using Physics-informed neural networks (PINNs), embedding physical laws and boundary conditions directly into the neural network architecture. Uddin et al. [2023]Ganga et al. [2024]

Novelty: The study integrates the effects of Hall and ion parameters, velocity and temperature slips, Ohmic heating, and thermal radiation within the framework of PINNs. It provides a novel approach to solve a three-dimensional MHD flow problems involving NEPCM-based nanofluids.

Findings: The results reveal that increasing Hall and ion parameters reduces the skin friction coefficient while enhancing heat transfer rates. The study demonstrates the effectiveness of PINNs in solving complex three-dimensional flow problems, offering significant insights for advancing thermal management and energy system designs.

Keywords: Nanofluid; Phase change; Wedge; Hall-Ion effect; PINN

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