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Magnetoradiative Nanofluid Convection in Darcy–Forchheimer Porous Media: Multiphysics Interaction and Thermal Control

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ABSTRACT

Steady magnetoradiative nanofluid flow over a stretched surface embedded in a Darcy-Forchheimer porous medium is analyzed numerically. Thermal radiation, thermophoresis and Brownian motion-induced nanoparticle transport, porous-medium resistance, viscous dissipation, and Joule heating are all included in the model inside a single boundary-layer framework. Similarity transformations are used to convert the governing partial differential equations into a coupled system of nonlinear ordinary differential equations using Buongiorno's nanofluid model and the Rosseland diffusion approximation. A robust shooting method in conjunction with Runge-Kutta integration is used to solve the resulting equations numerically. Grid-independence analysis and comparison with known benchmark solutions are used to confirm the accuracy of the solution. The findings show that thermal radiation greatly raises the effective thermal diffusivity, which leads to significant increases in the local Nusselt number, especially in low-permeability regimes, while porous resistance and magnetic forces significantly limit momentum transmission. Brownian motion encourages thermal mixing and heat transfer, while thermophoresis increases the migration of nanoparticles away from the heated surface, increasing mass transfer but perhaps decreasing wall heat transfer. Radiation can partially counteract the negative effects of porous drag, according to interaction analyses, resulting in several transport regimes controlled by the relative dominance of diffusive, resistive, and radiative mechanisms. For sophisticated thermal systems including nanofluids, porous media, and radiative conditions, the results offer design guidance and physical insight.

Keywords: *Magnetoradiative Nanofluid Flow, Darcy–Forchheimer Porous Medium, Thermal Radiation, Brownian Motion, Thermophoresis, Magnetohydrodynamics, Joule Heating.*