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Theoretical investigation of double diffusive convection and thermal radiation on the peristaltic transport of a chemically reactive Jeffrey nanofluid

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ABSTRACT

This work aims to investigate the effects of chemical reaction and thermal radiation on the double diffusive convection of hydromagnetic Jeffrey nanofluid over a symmetric porous channel. Multiple relevant technological applications of double diffusive convection exist in industry. These applications include thermal storage, geothermal engineering, fuel cells, drying procedures, and cooling electronic equipment. Using linear transformation, the governing equations are first converted from fixed to wave frame. The system's complexity is decreased by using a lubrication method. This scenario is theoretically controlled by a series of nonlinear partial differential equations that describe the temperature, velocity, concentration, and volume percent of nanoparticles in the fluid. Due to this complexity, we found the approximate solution using the homotopy perturbation technique (HPM). The influence of several physical characteristics on flow amounts is graphically displayed and discussed. The key outcome of this investigation is that the Brownian motion parameter, thermophoresis parameter, and Dufour number can all boost the fluid's temperature in the presence of double-diffusive convection. Furthermore, the outcomes are examined to ensure that, there are good agreements between the current and previous findings under certain conditions.

RESEARCH AIM

The primary goal of this work is to examine the double diffusive peristaltic non-Newtonian Jeffrey nanofluid flow in a porous symmetric channel as it is affected by chemical reactions, heat sources/sink, thermal radiation, Hall current, and tilted magnetic field.

LITERATURE SURVEY

- The impact of slip condition on double-diffusion convection of magneto-fourth-grade nanofluids with peristaltic propulsion through inclined asymmetric channels was investigated by Akram et al. in 2022.
- Kotnurkar et al. investigated the impact of double-diffusive bioconvection on multi-slip peristaltic flow of Jeffrey nanofluid in an asymmetric channel in 2023.
- The peristaltic motion of a non-Newtonian fluid in the presence of an inclined magnetic field, a porous media, and chemical reaction was studied in 2024 by Vijayaragavan et al.

PROBLEM FORMULATION

The following are the governing equations for an incompressible Jeffrey nanofluid in a two-dimensional symmetric porous channel:

$$\frac{\partial U}{\partial X} + \frac{\partial V}{\partial Y} = 0 \tag{1}$$

$$\rho_f \left(\frac{\partial}{\partial t^*} + U\frac{\partial}{\partial X} + V\frac{\partial}{\partial Y}\right) U = -\frac{\partial P}{\partial X} + \frac{\mu}{(1+\lambda)}\nabla^2 U - \frac{\sigma B_0^2}{(1+m^2)}(U cos\omega - V sin\omega) cos\omega$$
$$-\frac{\mu}{k}U + g\{(1-\Theta_0)\rho_{f_0}\{\beta_T(T-T_0) + \beta_C(C-C_0)\} - (\rho_p - \rho_{f_0})(\Theta - \Theta_0)\} \tag{2}$$

$$\rho_f \left(\frac{\partial}{\partial t^*} + U\frac{\partial}{\partial X} + V\frac{\partial}{\partial Y}\right) V$$
$$= -\frac{\partial P}{\partial Y} + \frac{\mu}{(1+\lambda)}\nabla^2 V + \frac{\sigma B_0^2}{(1+m^2)}(U cos\omega - V sin\omega) sin\omega - \frac{\mu}{k}V \tag{3}$$

$$\left(\frac{\partial}{\partial t^*} + U\frac{\partial}{\partial X} + V\frac{\partial}{\partial Y}\right) C = D_S\left(\frac{\partial^2 \mathrm{C}}{\partial X^2} + \frac{\partial^2 \mathrm{C}}{\partial Y^2}\right) + D_{CT}\left(\frac{\partial^2 \mathrm{T}}{\partial X^2} + \frac{\partial^2 \mathrm{T}}{\partial Y^2}\right) - k_r(C - C_0) \tag{4}$$

$$\left(\frac{\partial}{\partial t^*} + U\frac{\partial}{\partial X} + V\frac{\partial}{\partial Y}\right) \Theta = D_B\left(\frac{\partial^2 \Theta}{\partial X^2} + \frac{\partial^2 \Theta}{\partial Y^2}\right) + \left(\frac{D_T}{T_0}\right)\left(\frac{\partial^2 \mathrm{T}}{\partial X^2} + \frac{\partial^2 \mathrm{T}}{\partial Y^2}\right) \tag{5}$$

SOLUTION METHODOLOGY

An analytical method for resolving both linear and nonlinear differential equations is the homotopy perturbation Method (HPM). It turns a challenging problem into a sequence of easier problems by combining the homotopy technique with conventional perturbation methods. HPM is a flexible and widely applicable method because it does not require a small parameter in the equation, unlike typical perturbation methods. The method guarantees the convergence of the solution series by building a homotopy with an embedding parameter, which is regarded as a "small parameter." This often leads to extremely accurate approximations with fewer terms. Many disciplines, such as fluid dynamics, quantum physics, and financial mathematics, have successfully used HPM, demonstrating its dependability and effectiveness in solving challenging issues**.**

CONCLUSIONS

The effects of thermal radiation, chemical reaction, Hall current, double diffusive convection, and an inclined magnetic field are examined in this study in relation to mass and heat transfer in porous symmetric channels during Jeffrey fluid's peristaltic transit. The homotopy perturbation method was used to solve the non-linear differential equations. The main finding of this study is that in the presence of double-diffusive convection, the fluid's temperature can be increased by the Brownian motion parameter, thermophoresis parameter, and Dufour number (see figures 1 and 2).

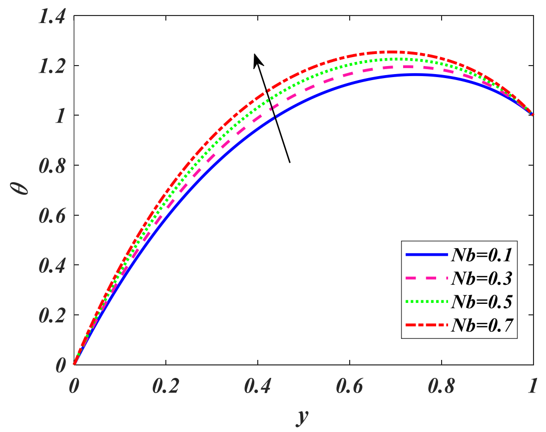

Figure. 1

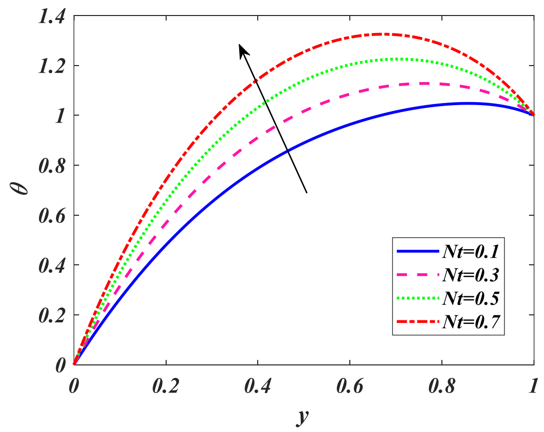

Figure. 2

REFERENCE

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