The Effects of Variable Viscosity and Thermal Conductivity of a MHD Micropolar Fluid Past a Continuously Moving Plate with Soret and Dufour Effects

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ABSTRACT
In the present work, the effects of variable viscosity and thermal conductivity on the boundary layer flow and heat and mass transfer of a MHD micropolar fluid past a continuously moving plate embedded in porous media with Soret and Dufour effects have been studied. Both viscosity and thermal conductivity are assumed to be the inverse linear functions of temperature. The governing partial differential equations are transformed into dimensionless forms using similarity transformations. The effects of variable viscosity, variable thermal conductivity and the other parameters involved in the study on the velocity, micro-rotation, temperature and concentration distribution profiles as well as skin fraction coefficients, couple stress, Nusselt number and Sherwood number are investigated by solving the governing transformed ordinary differential equations with the help of Runge-Kutta fourth order method with shooting technique and shown graphically and in tabulated form and discussed in detail.

Keywords
Variable viscosity, variable thermal conductivity, micropolar fluid, magnetic field, heat transfer, mass transfer, Soret and Dufour effects, shooting technique.

1. INTRODUCTION
The problems of micropolar flow and heat and mass transfer in the boundary layers of a continuously moving plate have been attracted considerable attention of researchers due to their numerous technological applications. Micropolar fluids are referred to those fluids that contain micro-constituents that can undergo rotation which affect the hydrodynamics of the flow. These fluids are distinctly non-Newtonian in nature. The concept of micropolar fluid was introduced by Eringen [1] where he derived the constitutive laws of fluid with micro structure and taking into account the effect of micro-elements of fluids on both the kinematics and conduction of heat, the theory of thermo-micropolar fluids has been developed by Eringen [2]. Micropolar fluid theory has been employed to study a number of flow situations such as the flow of low concentration suspensions, liquid crystals, real fluid with suspensions and animal blood etc. Over the years, the dynamics of micropolar fluids has been a popular area of research. A thorough review of the subject and the applications of micropolar fluid mechanics has been given by Ariman et al. [3,4]. Flow in the boundary layer on moving solid surface was historically first investigated by Sakiadis [5,6] who observed that the boundary layer growth is in the direction of motion of the continuous solid surface and deviates from that of the classical Blasius flow past a flat plate. Also, heat and mass transfers simultaneously affecting each other will also cause a cross- diffusion effect. The mass transfer caused by the temperature gradient is called the Soret effect, while the heat transfer caused by concentration gradient is called Dufour effect. Ishak et.al [7] discussed the problem of steady boundary layer flow and heat transfer of a micropolar fluid on an isothermal continuously moving surface. Gorla [8] studied mixed convection in a micropolar fluid from a vertical surface with uniform heat flux. Adrian [9] studied numerically the heat and mass transfer by natural convection from vertical surface in porous media in presence of magnetic field considering Soret and Dufour effects. The effects of Dufour and Soret on unsteady MHD free convection and mass transfer flow past a vertical porous plate was discussed by Alam et.al [10]. Hazarika [11] discussed the heat transfer between two parallel disks. Kafoussias et.al [12] studied the boundary layer flows in presence of Soret and Dufour effects associated with thermal diffusion and diffusion thermo for the mixed forced-natural convection. EL-Kabir et.al [13] studied the Soret and Dufour effects on heat and mass transfer from a continuously moving plate embedded in porous media with temperature dependent viscosity and thermal conductivity.

In the present study, an attempt has been made to incorporate the combined effects of variable viscosity and thermal conductivity on the boundary layer flow and heat and mass transfer of a MHD micropolar fluid over a continuously moving plate embedded in a porous medium with Soret and Dufour effects. Following Lai and Kulacki [14], the fluid viscosity and thermal conductivity are assumed to vary as an inverse linear function of temperature. Using similarity transformations the governing partial differential equations of motion are reduced to ordinary differential equations, which are solved numerically for prescribed boundary conditions by shooting technique.

2. MATHEMATICAL FORMULATION

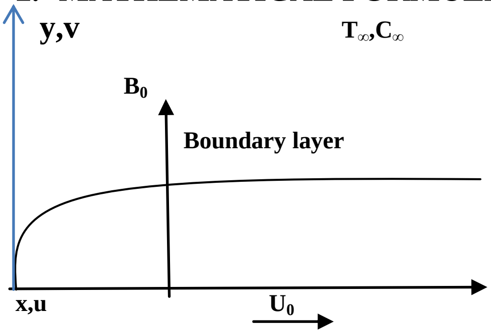

Fig 1: Physical model and coordinate system

The problem under consideration is a steady two dimensional laminar flow of an incompressible, electrically conducting fluid over a continuously moving plate embedded in a porous media. The x-axis is taken along the plate in the direction of the fluid motion and y-axis taken normal to it. A uniform magnetic field B_0 is imposed along y-axis. Then under the usual boundary layer approximations, the flow and heat and mass transfer of a MHD micropolar fluid in porous medium with Soret and Dufour effects included are governed by the following equations:

Basic Equations:

Continuity Equation:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad (1)$$

Momentum Equation:

$$u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}=\frac{1}{\rho}\frac{\partial}{\partial y}(\mu\frac{\partial u}{\partial y})+\frac{k}{\rho}(\frac{\partial N}{\partial y}+\frac{\partial^2 u}{\partial y^2})$$
$$-\frac{\mu}{K}u-K^*u^2-\frac{\sigma B_0^2}{\rho}u \qquad (2)$$

Angular momentum Equation:

$$\rho j(u\frac{\partial N}{\partial x}+v\frac{\partial N}{\partial y})=-k(2N+\frac{\partial u}{\partial y})+\gamma\frac{\partial^2 N}{\partial y^2} \qquad (3)$$

Energy Equation:

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\frac{1}{\rho c_p}\frac{\partial}{\partial y}(\lambda\frac{\partial T}{\partial y})$$
$$+\frac{1}{\rho c_p}(\mu+k)\left(\frac{\partial u}{\partial y}\right)^2+\frac{D_m\lambda_T}{c_p c_s}\frac{\partial^2 C}{\partial y^2} \qquad (4)$$

Concentration Equation:

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=\frac{\partial}{\partial y}(D_m\frac{\partial C}{\partial y})+\frac{D_m\lambda_T}{T_m}\frac{\partial^2 T}{\partial y^2} \qquad (5)$$

where u and v are the components of velocity along x and y-directions respectively, ρ is the fluid density, μ is the coefficient of dynamic viscosity, k is the vortex viscosity, N is the microrotation component, K is the permeability of the porous medium, K^* is the inertia coefficient, γ is the spin gradient viscosity, j is the micro-inertia density, T is the temperature of the fluid , λ is the thermal conductivity, c_p is the specific heat at the constant pressure, σ is the electrical conductivity, B_0 is the external magnetic field, C is the concentration of the fluid within the boundary layer, D_m is the molecular diffusivity of the species concentration. λ_T, c_p, c_s and T_m are the thermal diffusion ratio, specific heat at constant pressure, concentration susceptibility and mean fluid temperature respectively.

The boundary conditions are given as:

$$y=0: u=U_0,$$
$$v=0, N=-\frac{1}{2}\frac{\partial u}{\partial y}, T=T_w, C=C_w$$
$$y\to\infty: u\to 0, \quad N\to 0, T\to T_\infty, C\to C_\infty \qquad (6)$$

Where U_0 is the uniform velocity of the plate, T_w and C_w are the temperature and concentration on the surface, T_∞ and C_∞ are the temperature and concentration of the fluid at infinity. Following Lai and Kulacki [14] let us assume that,

$$\frac{1}{\mu}=\frac{1}{\mu_\infty}[1+\delta(T-T_\infty)] \text{ or } \frac{1}{\mu}=\zeta(T-T_r) \text{ where}$$
$$\zeta=\frac{\delta}{\mu_\infty} \text{ and } T_r=T_\infty-\frac{1}{\delta}$$

$$\frac{1}{\lambda}=\frac{1}{\lambda_\infty}[1+\xi(T-T_\infty)] \text{ or } \frac{1}{\lambda}=\varepsilon(T-T_c) \text{ where}$$
$$\varepsilon=\frac{\xi}{\lambda_\infty} \text{ and } T_c=T_\infty-\frac{1}{\xi} \qquad (7)$$

Where μ_∞ is the viscosity at infinity, ζ and T_∞ are constants, T_r is transformed reference temperature, δ and ξ are constants based on thermal property of the fluid. Similarly, λ_∞ is the thermal conductivity at the infinity, ε and T_c are constants and their values depend on the reference state and thermal properties of the fluid.

To solve equations (1)-(5) subject to the boundary conditions given in equation (6) the following similarity transformations have been used,

$$\eta=(\frac{U_0}{2\upsilon_\infty x})^{\frac{1}{2}}y, \psi=(2\upsilon_\infty U_0 x)^{\frac{1}{2}}f(\eta),$$
$$N=U_0(\frac{U_0}{2\upsilon_\infty x})^{\frac{1}{2}}g(\eta),$$
$$\theta(\eta)=\frac{T-T_\infty}{T_w-T_\infty}, \quad \phi(\eta)=\frac{C-C_\infty}{C_w-C_\infty},$$
$$u=\frac{\partial\psi}{\partial y}, v=-\frac{\partial\psi}{\partial x} \qquad (8)$$

Where η is the similarity parameter and υ_∞ is the kinematic viscosity at $T = T_\infty$.

Also from equations (7) and (8),

$$\upsilon = -\upsilon_\infty \frac{\theta_r}{\theta - \theta_r}, \lambda = -\lambda_\infty \frac{\theta_c}{\theta - \theta_c} \qquad (9)$$

Where θ_r and θ_c are the dimensionless parameters characterising the influence of viscosity and thermal conductivity respectively and are given by,

$$\theta_r = \frac{T_r - T_\infty}{T_w - T_\infty} = -\frac{1}{\delta(T_w - T_\infty)},$$

$$\theta_c = \frac{T_c - T_\infty}{T_w - T_\infty} = -\frac{1}{\xi(T_w - T_\infty)} \qquad (10)$$

Equation of continuity in equation (1) is identically satisfied using equation (8) and therefore the velocity field is compatible with continuity equation and represents the possible fluid motion.

Using equations (8) - (10) in equations (2)-(5) the following differential equations are obtained:

$$(\frac{\theta_r}{\theta - \theta_r} - K) f''' = [\frac{\theta_r}{(\theta - \theta_r)^2} \theta' + f] f'' - \alpha (f')^2$$

$$+ (\frac{\theta_r}{\theta - \theta_r} \frac{1}{Da} - M) f' + K_1 g' \qquad (11)$$

$$g'' = -\frac{1}{\Delta}(f'g + fg') - \frac{1}{G}(2g + f'') \qquad (12)$$

$$(\frac{\theta_c}{\theta - \theta_c})\theta'' = \Pr f\theta' + \left\{\frac{\theta_c}{(\theta - \theta_c)^2}\right\}(\theta')^2$$

$$+ \Pr Ec(K_1 - \frac{\theta_r}{\theta - \theta_r})(f'')^2 + D_f P_r \phi'' \qquad (13)$$

$$\frac{\theta_r}{\theta - \theta_r}\phi'' = \frac{\theta_r}{(\theta - \theta_r)^2}\theta'\phi' + S_c f \phi' + S_c S_r \theta'' \qquad (14)$$

Where the primes denote differentiation with respect to η,

$K_1 = \frac{k}{\mu_\infty}$ is the coupling constant parameter,

$Da = \frac{KU_0^2}{2\rho \operatorname{Re} \upsilon_\infty^2}$ is the Darcy number ,

$M = \frac{2\sigma B_0^2 x}{\rho U_0}$ is the magnetic parameter , $\alpha = 2K^* x$ is the inertia coefficient parameter,

$\Delta = \frac{\gamma}{\mu_\infty j}$ is the material constant , $G = -\frac{\gamma U_0}{2k\upsilon_\infty x}$ is the local microrotation parameter,

$\Pr = \frac{\upsilon_\infty \rho c_p}{\lambda_\infty}$ is the Prandtl number,

$Ec = \frac{U_0^2}{c_p (T_w - T_\infty)}$ is the Eckert number,

$S_c = \frac{\upsilon}{D_m}$ is the Schmidt number,

$S_r = \frac{D_m \lambda_T (T_w - T_\infty)}{T_m (C_w - C_\infty)\upsilon_\infty}$ is the Soret number,

$D_f = \frac{D_m \lambda_T (C_w - C_\infty)}{c_p c_s (T_w - T_\infty)\upsilon_\infty}$ is the Dufour number,

$\operatorname{Re} = \frac{U_0 x}{\upsilon_\infty}$ is the Reynolds number.

The transformed boundary conditions are,

$$f(0) = 0,\ f'(0) = 1,\ g(0) = -\frac{1}{2} f''(0),\ \theta(0) = 1,$$
$$\phi(0) = 1$$

$$f'(\infty) = 0,\ g(\infty) = 0,\ \theta(\infty) = 0,\ \phi(\infty) = 0 \qquad (15)$$

The four important physical quantities of our interest in the problem are the skin friction co-efficient (c_f), the wall couple stress (m_w), Nusselt number (Nu) and Sherwood number (Sh) are defined as,

$c_f = \frac{2\tau_w}{\rho U_0^2}$ where the shear stress at the surface is given by ,

$$\tau_w = [(\mu + k)\frac{\partial u}{\partial y} + kN]_{y=0},$$

$m_w = \gamma \frac{U_0^2}{2\upsilon_\infty x} g'(0)$, $Nu = \frac{x q_w}{\lambda_\infty (T_w - T_\infty)}$, where the heat flux is given by , $q_w = -\lambda[\frac{\partial T}{\partial y}]_{y=0}$,

$Sh = -\frac{Js}{U_0 (C_w - C_\infty)}$ where $Js = [-D_m \frac{\partial C}{\partial y}]_{y=0}$

Therefore,

$$c_f (2\operatorname{Re})^{1/2} = (\frac{2\theta_r}{\theta_r - 1} + K_1) f''(0),$$

$$m_w = \gamma \frac{U_0^2}{2\upsilon_\infty x} g'(0),$$

$$Nu\,\mathrm{Re}^{-1/2}\,2^{1/2} = \frac{\theta_c}{1-\theta_c}\theta'(0) \text{ and}$$

$$Sh(2\,\mathrm{Re})^{1/2} = -\frac{\theta_r}{1-\theta_r}S_c^{-1}\phi'(0)$$

3. RESULTS AND DISCUSSION

The system of coupled non-linear ordinary differential equations (11)-(14) together with the boundary conditions (15) is solved numerically by using the fourth order Runge-Kutta method along with the shooting technique. The numerical values of different parameters are taken as θ_c = -5, θ_r =-5, M=.1, S_r =.4, G=2, P_r =.7, Ec=.1, K1=1, Δ =1, S_c=1, D_f=.15, α=.3, unless otherwise stated. The purpose of this study is to bring out the effects of variable viscosity and thermal conductivity on the governing flow with the combination of the other flow parameters. The numerical computations have been carried out by developing codes for MATLAB and results are presented graphically in order to get a physical insight of the problem for the dimensionless velocity profile f´(η), dimensionless microrotation profile g(η), temperature profile θ(η) and concentration profile ϕ(η) with the variation of different parameters in figures 2-23. In several practical problems, the surface characteristics such as skin-friction, wall couple stress, Nusselt number and Sherwood number play important roles and hence, the missing values of f´´(0), g´(0), θ´(0) and ϕ´(0) for various values of viscosity parameter θ_r, thermal conductivity parameter θ_c, microratation parameter G, Magnetic parameter M, Dufour number D_f, and Soret number S_r have been derived in tables 1-4.

Figures 2-5 display the influence of viscosity parameter θ_r, Darcy number Da, magnetic parameter M and microrotation parameter G on velocity distribution. From fig.2 it is observed that velocity decreases with the increasing values of viscosity parameter. Since, by definition viscosity is inversely proportional to the velocity and hence the result is obvious. Fig.3 depicts the effect of Darcy number on velocity profiles. Physically, Darcy number is directly proportional to the permeability which causes higher restriction to the fluid flow which in turn slows its motion. From fig.4, it is observed that velocity reduces due to the increasing values of magnetic parameter M and it is due to the fact that the presence of magnetic field produces a Lorentz force which usually resists the momentum field; whereas from fig.5, it is observed that velocity enhances with the increasing values of microrotation parameter G because for small values of G, the viscous force is predominant as a result viscosity increases and consequently velocity decreases. Figures 6-10 depict the influence of viscosity parameter θ_r, Darcy number Da, magnetic parameter M, microrotation parameter G and Dufour number D_f on microrotation distribution profiles. From figures 6-8, it is observed that microrotation distribution increases with the increasing values of θ_r, Da and M while reverse trend is observed from the figures 9 and 10 for the increasing values of G and D_f respectively. Due to the increase of viscous force and Lorentz force temperature of the fluid increases, so molecules get released from their bonds holding them as a result rotation of the fluid elements increased as shown in figures 6, 7 and 8. Figures 11-18 represents temperature profiles for various parameters. Effect of thermal conductivity parameter θ_c is observed in fig.11 and it has been found that temperature decreases with the increasing values of thermal conductivity parameter θ_c because due to the increase of thermal conduction the transposition of heat from a region of higher temperature to the region of lower temperature increases, so the temperature of the fluid within the boundary layer decreases. From the figures12-14 it has been observed that temperature decreases with the increasing values of microrotation parameter G, Soret number S_r and Prandtl number Pr respectively. Since Soret number defines the effect of the temperature gradients including significant mass diffusion effects and hence temperature reduces significantly as shown in the fig.13. The effect of Prandtl number is exhibited in fig.14 and the graph depicts that the thermal boundary layer thickness decreases as Pr increases due to the fact that higher Prandtl number fluid has relatively low thermal conductivity which reduces conduction and there by temperature decreases. Again from the figures 15-18, it is observed that for the increasing values of Darcy number Da, Dufour number D_f , viscosity parameter θ_r, and magnetic parameter M respectively the temperature profile increases significantly. Since Dufour number signifies the contribution of the concentration gradients to the thermal energy flux in the flow and hence from fig.16 it is clearly seen that as D_f increases there is a monotonic increase in the temperature profile. Also, increase of viscosity parameter θ_r and magnetic parameter M lead to the increase of viscous force and Lorentz force respectively. These forces give resistance to the flow of the fluid and the fluid has to work done to overcome these resistances. These energies transformed into thermal energy resulting the temperature of the fluid increases as exhibited in figures 17 and 18. Figures 19-23 represents concentration profile for the various parameters. From the figures 19, 20 and 21 it is noticed that concentration boundary layer thickness decreases as viscosity parameter θ_r, Dafour number D_f and Schmidt number Sc enhance. Since Schmidt number characterizes the ratio of viscosity and mass diffusion, that is, it is inversely proportional to mass diffusion and hence as a result species concentration reduces which is clearly observed in fig. 21. Concentration boundary layer thickness is found to be enhanced significantly due to the increasing values of Darcy number Da and Soret number Sr respectively as shown as in the figures 22 and 23.

From tables 1 and 2, it is observed that, with the increasing values of viscosity parameter θ_r , the values of f´´(0), g´(0) and ϕ´(0) are decreasing while θ´(0) increases and for increasing values of thermal conductivity parameter θ_c, the values of f´´(0) and θ´(0) decreases; but g´(0) and ϕ´(0) increases. Also for increasing values of microrotation parameter G, all the values of f´´(0), g´(0), θ´(0) and ϕ´(0) decreases and for that of magnetic parameter M, the values of f´´(0) and g´(0) decreases whereas the values of θ´(0) and ϕ´(0) increases significantly. Tables 3 and 4 depicts a comparison of the present work with the earlier published work of EL-Kabir et al.[13] for various values of Dufour number D_f and Soret number S_r and a significant result has been obtained in the present work and it is found that the behavior of Dufour number and Soret number on temperature and concentration distribution is opposite which remains same with the previous work.

Figures 2-23 for dimensionless velocity distribution f′(η), dimensionless microrotation distribution g(η), temperature distribution θ(η) and concentration distribution Φ(η) with the variation of different parameters and missing value tables and comparison tables 1-4 are displayed below :

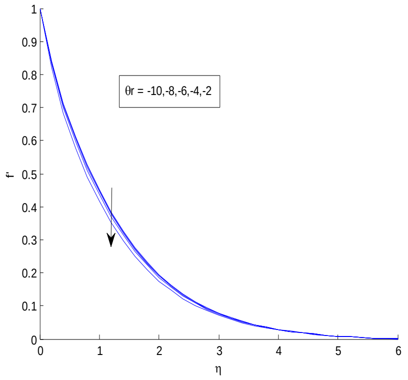

Fig 2: Velocity for various θ_r

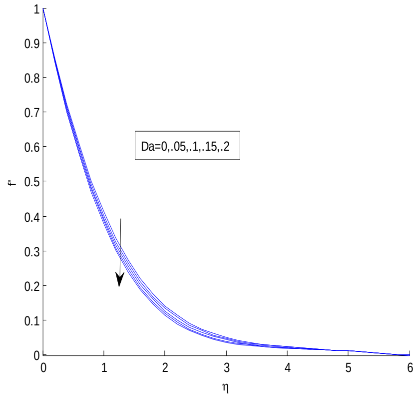

Fig 3: Velocity for various Da

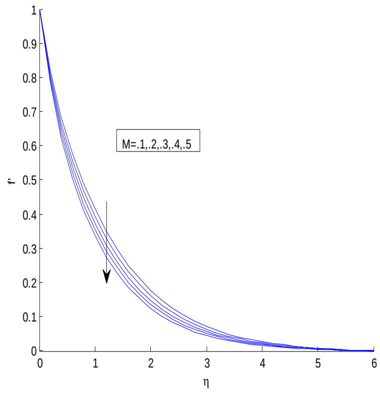

Fig 4: Velocity for various M

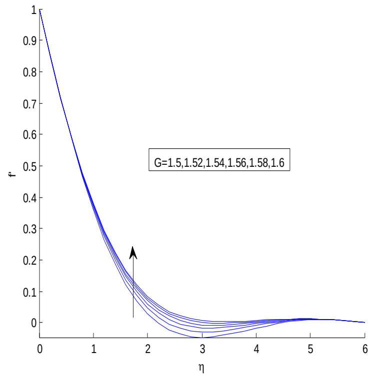

Fig 5: Velocity for various G

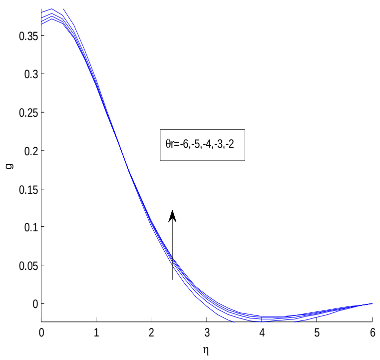

Fig 6: Microrotation for various θ_r

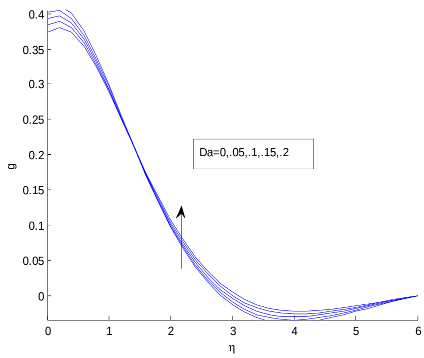

Fig 7: Microrotation for various Da

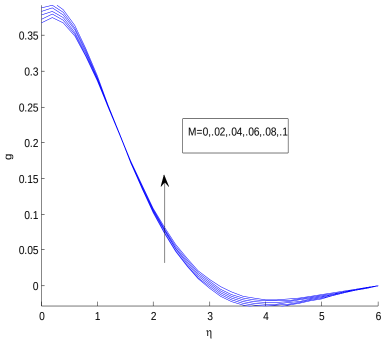

Fig 8: Microrotation for various M

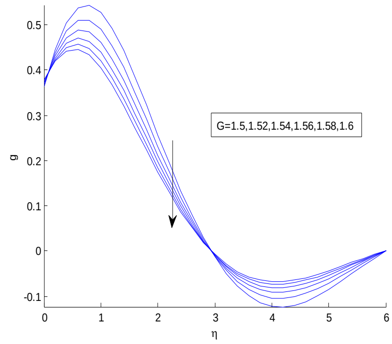

Fig 9: Microrotation for various G

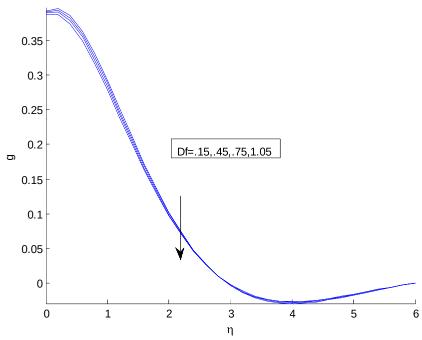

Fig 10: Microrotation for various D_f

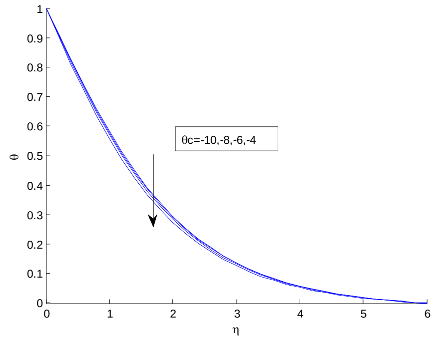

Fig 11: Temperature for various θ_c

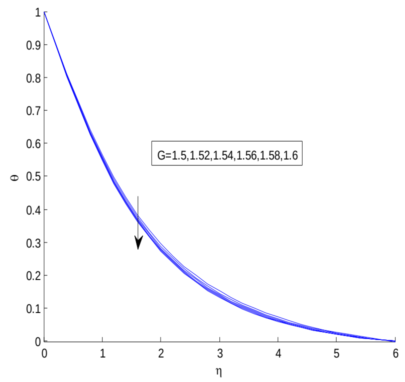

Fig 12: Temperature for various G

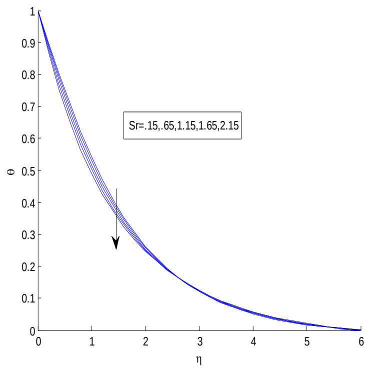

Fig 13: Temperature for various S_r

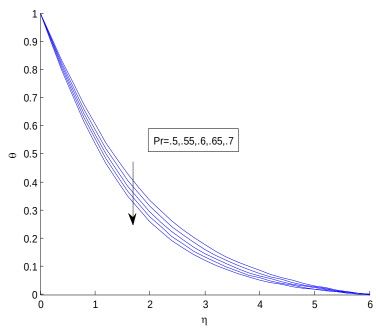

Fig 14: Temperature for various Pr

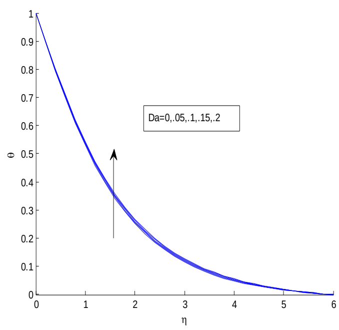

Fig 15: Temperature for various Da

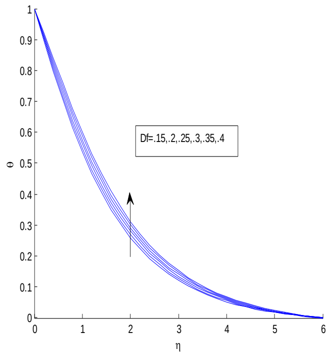

Fig 16: Temperature for various D_f

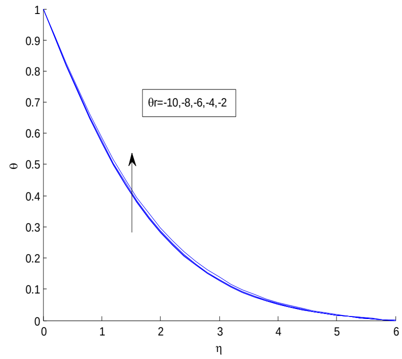

Fig 17: Temperature for various θ_r

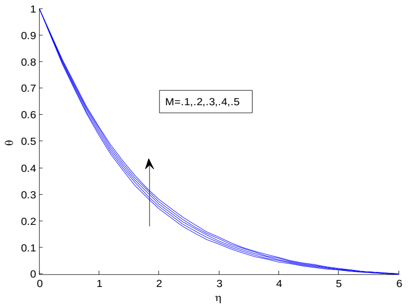

Fig 18: Temperature for various M

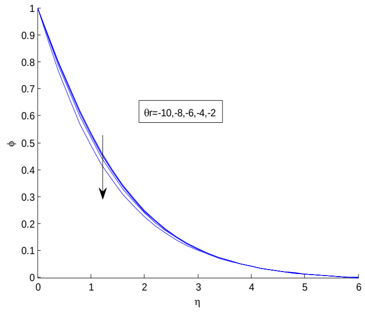

Fig 19: Concentration for various θ_r

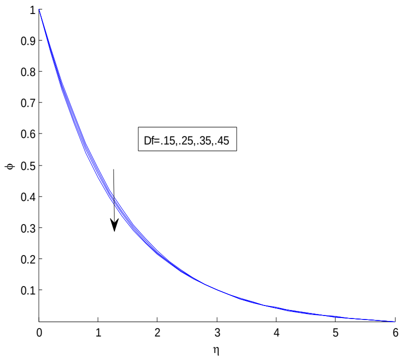

Fig 20: Concentration for various D_f

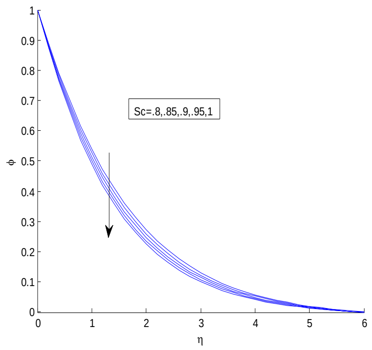

Fig 21: Concentration for various S_c

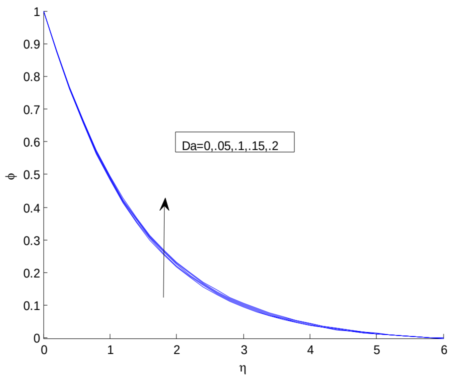

Fig 22: Concentration for various D_a

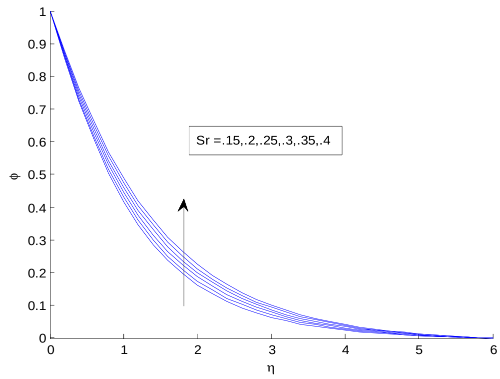

Fig 23: Concentration for various S_r

Table 1: Estimated missing values of $f''(0)$, $g'(0)$, $\theta'(0)$ and $\phi'(0)$for various θ_r and G and θ_c = -5, D_f=.15, M=.1, Pr =.7, Ec=.10, K_1=1, Δ =.1, S_c=1, S_r=.4,α=.3,Da=.1

G	θ_r	f´´(0)	g´(0)	θ´(0)	ϕ´(0)
1.50	-10	-0.71943	0.080101	-0.47045	-0.55088
	-7	-0.7289	0.075336	-0.4671	-0.56484
	-4	-0.75067	0.064414	-0.4591	-0.59868
1.80	-10	-0.72488	0.035787	-0.47251	-0.552
	-7	-0.73481	0.029353	-0.46923	-0.566
	-4	-0.75765	0.014739	-0.46137	-0.59994
2.10	-10	-0.72874	0.008865	-0.47355	-0.55256
	-7	-0.73917	0.000529	-0.4703	-0.56658
	-4	-0.76321	-0.0183	-0.46252	-0.60056

Table 2: Estimated missing values of f´´(0) , g´(0), θ´(0) and ϕ´(0)for various θ_c and M and θ_r = -5, D_f=.15,G=2, Pr =.7, Ec=.10,K_1=1, Δ =.1, S_c=1, S_r=.4,α=.3,Da=.1

M	θ_c	f´´(0)	g´(0)	θ´(0)	ϕ´(0)
.1	-10	-0.75031	-0.00046	-0.43686	-0.59575
	-7	-0.75047	-0.00032	-0.44935	-0.59099
	-4	-0.75084	0.000016	-0.47996	-0.57929
.2	-10	-0.7998	-0.0348	-0.42634	-0.5891
	-7	-0.79996	-0.03467	-0.43853	-0.58442
	-4	-0.80034	-0.03436	-0.46841	-0.57293
.3	-10	-0.84632	-0.06391	-0.41612	-0.58277
	-7	-0.84648	-0.06378	-0.42802	-0.57817
	-4	-0.84687	-0.06349	-0.45718	-0.56688

Table 3: Comparison of missing values of f´´(0) , θ´(0) and ϕ´(0) at θ_r =-5,G =2, θ_c = -5, M=.1, Pr =.7, Ec =.10, K_1=1, Δ =.1, S_c=1, S_r=.4, α=.3, Da=.1, S_r =.4 for different values of D_f with previously published result of EL-Kabir et. al [13].

Previous work, EL-Kabir et. al [13]				Present work		
D_f	f″(0)	θ′(0)	Φ′(0)	f″(0)	θ´(0)	Φ′(0)
.2	-1.34183	-1.01378	-0.37060	-0.76108	-0.44511	-0.60718
.3	-1.35694	-0.85340	-0.52699	-0.76053	-0.40932	-0.62139
.4	-1.37165	-0.69015	-0.60611	-0.75997	-0.37119	-0.63655

Table 4: Comparison of missing values of f´´(0) , θ´(0) and ϕ´(0) at θ_r =-5,G =2, θ_c = -5, M=.1, Pr =.7, Ec=.10, K_1=1, Δ =.1, S_c=1, S_r=.4, α=.3, Da=.1, D_f =.15 for different values of S_r with previously published result of EL-Kabir et. al [13].

Previous work, EL-Kabir et. al [13]				Present work		
S_r	f″(0)	θ′(0)	Φ′(0)	f″(0)	θ´(0)	Φ′(0)
.4	-1.34183	-1.01378	-0.37060	-0.76135	-0.4622	-0.60039
.3	-1.35694	-0.85340	-0.52699	-0.7613	-0.45876	-0.63141
.2	-1.37165	-0.69015	-0.60611	-0.76125	-0.45539	-0.66175

4. CONCLUSION:

In this study the effects of variable viscosity and thermal conductivity on the boundary layer flow and heat and mass transfer of a MHD micropolar fluid over a continuously moving plate embedded in a porous medium with Soret and Dufour effects is studied and the following significant observations are made:

1. Velocity distribution reduces due to the increasing values of viscosity parameter θ_r, magnetic parameter M and Darcy number Da and it increases with the increasing values of microrotation parameter G.
2. Microrotation distribution enhances due to the increase of viscosity parameter θ_r, magnetic parameter M and Darcy number Da, while it reduces with the increasing values of microrotation parameter G and Dufour number D_f.
3. Temperature distribution decreases due to the increase of thermal conductivity parameter θ_c, microrotation parameter G, Soret number S_r and Prandtle number Pr; while opposite trend is observed with the values of Darcy number Da, Dufour number D_f, viscosity parameter θ_r and magnetic parameter M.
4. Concentration distribution reduces due to the increase of viscosity parameter θ_r, Dufour number D_f and Schmidt number S_c while it increases with Darcy number Da and Soret number S_r .
5. With the increasing values of viscosity parameter θ_r, the values of $f''(0)$, $g'(0)$ and $\phi'(0)$ are decreasing while $\theta'(0)$ increases and for increasing values of thermal conductivity parameter θ_c, the values of $f''(0)$ and $\theta'(0)$ decreases; but $g'(0)$ and $\phi'(0)$ increases.
6. It is hoped that the findings of this paper will be helpful for further research work in heat and mass transfer problems.

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