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Hydromagnetic Instability of visco-elastic Walter's (modal B′) nanofluid layer heated from below under the effect of rotation

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Abstract

Hydro magnetic Instability of visco-elastic Walter's (modal B′) nanofluid layer heat from below is studied under the effect of rotation. The dispersion relation is obtained by using normal mode technique and perturbation method. The effects of the various physical parameters of the system namely modified diffusivity ratio, Lewis number, nanoparticle Rayleigh number, magnetic field and rotation on the stationary deportation have been discussed both analytically and graphically. The Lewis number, modified diffusivity ratio and nano particle Rayleigh number and rotation are found to have destabilizing effect whereas magnetic field has a stabilizing effect for stationary deportation.

Keywords-

Walter's (modal B′) visco-elastic fluid; Normal mode technique; Lewis number; modified diffusivity ratio; magnetic field, rotation.

1. Introduction

Chandrasekhar [1] has explained in detail the thermal instability of a Newtonian fluid under the assumptions of hydrodynamics and hydromagnetics. Bhatia and Steiner [2] have discussed the thermal impermanence of a Maxwellian visco-elastic fluid in the presence of a magnetic field. The thermohaline deportation in a layer of fluid heated from below has been studied by Veronis [3]. There are a number of applications of nanofluids in various industrial fields such as pharmaceutical, automotive, energy, oil fields. The term nanofluids was firstly discussed by Choi [4]. A nanofluid is a colloidal mixture of nano sized particles. It is experimentally proved that nanoparticles increases the thermal conductivity of fluids due to which nanofluids has developed considerable research interest. Sharma [5] has studied the thermal instability of a layer of visco-elastic fluid acted on by a uniform rotation and resulted that rotation has destabilizing effect as well as stabilizing effects under certain conditions. The effect of suspended particles and compressibility on thermal deportation in a Walter's (modal B') visco-elastic fluid in hydrodynamics have been observed by Sharma and Aggarwal [6]. S.Pundir, D.Kapil and R.Pundir [7] have studied effect of rotation on hydromagnetic instability of visco-elastic Rivlin-Ericksen nanofluid layer heated from below and resulted that rotation shows stabilizing effect on the fluid layer. The effect of rotation on thermal deportation in nanofluid layer saturating a Darcy-Brinkman porous medium has been observed by Chand and Rana [8]. Thermal instability of Walter's (modal B') visco-elastic nanofluid layer heated below under magnetic field has been studied by D. Kapil and S. Pundir [9] and investigated that magnetic field has stabilizing effect on the fluid layer. Yadav et al. [10] investigated the effect of magnetic field on the onset of nanofluid deportation and found that the volumetric fraction of nanoparticles, the Lewis number, the modified diffusivity and the density ratios have a stabilizing effect, while the magnetic field has stabilizing effect on the system. Thermal instability in a rotating porous layer saturated by a non- Newtonian nanofluid with thermal conductivity and viscosity variation have been by studied D. Yadav et al.[11]. R. Bhargava et al. [12] have studied the thermal instability in a nanofluid layer with a vertical magnetic field.

The objective of the present paper is to study hydromagnetic instability of visco-elastic Walter's (modal B') nanofluid layer heated from below under the effect of rotation.

2. Mathematical Formulation

Suppose the horizontal layers of Walter's (modal B') visco-elastic nanofluid of infinite length and thickness d^* is bounded by $z = 0$ and $z = d^*$ and heated from below. The fluid layer is acting in upward direction under gravity force g (0,0,-g). T_0 and φ_0 are the temperature and volumetric fraction of nano particles at $z = 0$ and T_1, φ_1 are temperature and volumetric fraction at $z = d^*$ respectively. Thermo physical properties are constant for the analytical formulation.

The governing equation for visco-elastic Walter's (modal B') nanofluid

$$\nabla \boldsymbol{q}_d = 0 \tag{1}$$

$$\rho \frac{d\boldsymbol{q}_d}{dt} = -\nabla \mathrm{p} + \rho \mathrm{g} + \left(\mu - \mu' \frac{\partial}{\partial t}\right)\nabla^2 \boldsymbol{q}_d + \frac{\mu_e}{4\pi}(\boldsymbol{H}\nabla)\boldsymbol{H} + 2\rho(\boldsymbol{q}_d \times \Omega) \tag{2}$$

where $\frac{d}{dt} = \frac{\partial}{\partial t} + (\boldsymbol{q}_d.\nabla)$ stands for convection derivative, $\boldsymbol{q}_d$(u,v,w) is the velocity vector, p is the hydrostatic pressure, μ and μ′ are the viscosity and kinematic visco-elasticity respectively and g(0, 0, -g) is acceleration due to gravity, μ_e is the fluid magnetic permeability and H is the magnetic field and fluid is acted upon by a uniform rotation $\Omega(0,0,\Omega)$. The density ρ of nanofluid can be written as

$$\rho = \varphi\,\rho_p + (1-\varphi)\rho_f \tag{3}$$

where φ is the volume fraction of nano particles, ρ_p and ρ_f are the densities of nano particles and base fluid respectively.

The equation of motion for visco-elastic Walter's (modal B′) nanofluid is given as:

$$\rho\frac{d\boldsymbol{q}_d}{dt} = -\nabla \mathrm{p} + \left(\varphi\,\rho_p + (1-\varphi)\{\rho\left(1-\alpha(T-T_0)\right)\}\right)\mathrm{g} + \left(\mu - \mu'\frac{\partial}{\partial t}\right)\nabla^2\boldsymbol{q}_d + \frac{\mu_e}{4\pi}(\mathbf{H}.\nabla)\mathbf{H} + 2\rho(\boldsymbol{q}_d \times \Omega) \tag{4}$$

where α is the coefficient of thermal expansion and μ_e is the fluid magnetic permeability.

The continuity equation for the nano particles is

$$\frac{\partial\varphi}{\partial t} + \boldsymbol{q}_d\,\nabla\varphi = D_B\,\nabla^2\varphi + \frac{D_T}{T_1}\nabla^2 T \tag{5}$$

where D_B is the Brownian diffusion coefficient and D_T is the Thermoporetic diffusion coefficient of the nano particles.

The energy equation in nanofluid is

$$\rho_c\left(\frac{\partial T}{\partial t} + \boldsymbol{q}_d\,\nabla T\right) = k\nabla^2\mathrm{T} + (\rho_c)_p\left(D_B\nabla\varphi.\nabla T + \frac{D_T}{T_1}\nabla T.\nabla T\right) \tag{6}$$

Where ρ_c is the heat capacity of fluid, $(\rho_c)_p$ is the heat capacity of nano particles and k is the thermal conductivity. The Maxwell equation being

$$\frac{\partial\boldsymbol{H}}{\partial t} + (\boldsymbol{q}_d\nabla)\boldsymbol{H} = (\boldsymbol{H}\,\nabla)\boldsymbol{q}_d + \eta\,\nabla^2\mathbf{H} \tag{7}$$

$$\nabla\mathbf{H} = 0 \tag{8}$$

Where η is the fluid electrical resistivity.

Introducing non-dimensional variables as:

$$(x', y', z') = \left(\frac{x,\ y,\ z}{d^*}\right),$$

$$\boldsymbol{q}_{d'}(u', v', w') = \boldsymbol{q}_d\left(\frac{u,\ v,\ w}{k}\right)d^*,\ t' = \frac{tk}{d^{*2}},$$

$$p' = \frac{p}{\rho k^2}d^{*2},\ \varphi' = \frac{\varphi-\varphi_0}{\varphi_1-\varphi_0},$$

$$\mathrm{T}' = \frac{T-T_0}{T_0-T_1},$$

where $\frac{k}{\rho_c}$ = k is the thermal diffusivity of the fluid.

Equations (1), (4), (5), (6), (7) and (8), in non-dimensional form can be written as:

$$\nabla\boldsymbol{q}_d = 0 \tag{9}$$

$$\frac{1}{p_{r_1}}\frac{\partial\boldsymbol{q}_d}{\partial t} = -\nabla\mathrm{p} + (1-\mathrm{nF})\nabla^2\boldsymbol{q}_d - \mathrm{R_m}\hat{\mathrm{e}}_z - \mathrm{R_n}\varphi\hat{\mathrm{e}}_z - \mathrm{R_a}\mathrm{T}\hat{\mathrm{e}}_z + \mathrm{Q}\,\frac{p_{r_1}}{p_{r_2}}(\boldsymbol{H}.\nabla)\boldsymbol{H} + \frac{2d^{*2}\rho}{\mu}(\boldsymbol{q}_d \times \Omega) \tag{10}$$

$$\frac{\partial\varphi}{\partial t} + \boldsymbol{q}_d\nabla\varphi = \frac{1}{L_e}\nabla^2\varphi + \frac{N_A}{L_e}\nabla^2 T \tag{11}$$

$$\frac{\partial T}{\partial t} + \boldsymbol{q}_d\,\nabla T = \nabla^2\mathrm{T} + \frac{\mathrm{N_B}}{L_e}\nabla\varphi.\nabla T + \frac{N_A N_B}{L_e}\nabla T.\nabla T \tag{12}$$

$$\frac{\partial H}{\partial t} + (\boldsymbol{q}_d\,\nabla)\boldsymbol{H} = (\boldsymbol{H}\,\nabla)\boldsymbol{q}_d + \frac{p_{r_1}}{p_{r_2}}\nabla^2\boldsymbol{H} \tag{13}$$

$$\nabla\boldsymbol{H} = 0 \tag{14}$$

[The dashes (`) have been dropped for simplicity]

Here non-dimensional parameters are:

Lewis number $L_e = \frac{k}{D_B}$, Prandtl number $p_{r_1} = \frac{\mu}{\rho k}$, Magnetic Prandtl number $p_{r_2} = \frac{\mu}{\rho\eta}$, Rayleigh number $\mathrm{R_a} = \frac{\rho g\alpha d^{*3}}{\mu k}(\mathrm{T_0} - \mathrm{T_1})$,Basic- density Rayleigh number $\mathrm{R_m} = \frac{[\rho_p\varphi_0 + \rho(1-\varphi_0)]g\,d^{*3}}{\mu k}$, Nano particle Rayleigh number $\mathrm{R_n} =$

$\frac{(\rho_p-\rho)(\varphi_1-\varphi_0)g\,d^{*3}}{\mu k}$, Kinematic visco-elasticity parameter F=$\frac{\mu'}{\rho d^{*2}}$, Modified diffusivity ratio $N_A = \frac{D_T}{D_B T_1(\varphi_1-\varphi_0)}(T_0 - T_1)$, Modified particle density increment $N_B = \frac{(\rho_c)_p(\varphi_1-\varphi_0)}{(\rho_c)_f}$, Chandrasekhar number Q= $\frac{\mu_e H_0^2 d^{*2}}{4\pi\nu\rho\eta}$, Taylor number $T_A = \left(\frac{2d^{*2}\Omega}{\upsilon}\right)^2$

We assume that temperature and volumetric fraction of nano particles are constant on boundaries. Thus the dimensionless boundaries conditions are

$$w = 0, T = 1, \varphi = 0 \;\; at \;\; z = 0 \tag{15}$$

and $$w = 0, T = 0, \varphi = 1 \;\; at \;\; z = 1 \tag{16}$$

2.1) Basic States and its solution

The basic state of nanofluid is supposed to be time independent of time and can be written as

$q_d'(u,v,w) = 0,\; p' = p(z),\; T' = T_b(z),\; \varphi' = \varphi_b(z),$ Equations (9) to (12) using boundary conditions (15) and (16) give solution as:

$$T_b = 1 - z \;\text{ and }\; \varphi_b = z \tag{17}$$

2.2) Perturbation solution

The stability of the system can be studied by introducing small perturbations to primary flow, and written as

$$q_d'(u,v,w) = 0 + q_d''(u,v,w),\; T' = T_b + T'', \varphi' = \varphi_b + \varphi'',\; p' = p_b + p'', \text{with } T_b = 1 - z \text{ and } \varphi_b = z \tag{18}$$

Using equation (18) in equation (9) to (12) and linearize by neglecting the product of the prime quantities, we obtain the following equations:

$$\nabla \boldsymbol{q}_d = 0 \tag{19}$$

$$\frac{1}{p_{r_1}}\frac{\partial w}{\partial t}\hat{e}_z = (1-nF)\hat{e}_z\frac{\partial^2 w}{\partial z^2} - R_n\varphi\hat{e}_z + R_a T\hat{e}_z + Q\,\frac{p_{r_1}}{p_{r_2}}\frac{\partial \mathbf{H}}{\partial z}\hat{e}_z + \frac{2d^{*2}\rho\Omega w\hat{e}_z}{\boldsymbol{\mu}} \tag{20}$$

$$\frac{\partial \varphi}{\partial t} + w = \frac{1}{L_e}\nabla^2\varphi + \frac{N_A}{L_e}\nabla^2 T \tag{21}$$

$$\frac{\partial T}{\partial t} - w = \nabla^2 T + \frac{N_B}{L_e}\left(\frac{\partial T}{\partial z} - \frac{\partial \varphi}{\partial z}\right) - 2\frac{N_A N_B}{L_e}\frac{\partial T}{\partial z} \tag{22}$$

$$\frac{\partial \boldsymbol{H}}{\partial t} = \frac{\partial w}{\partial z}\hat{e}_z + \frac{p_{r_1}}{p_{r_2}}\nabla^2\boldsymbol{H} \tag{23}$$

$$\nabla \mathbf{H} = 0 \tag{24}$$

The dashes (′′) have been dropped for simplicity.

Since R_m is just a measure of basic static pressure gradient so it is not involved in these and subsequent equations. Now by operating Eq. (20) with $\hat{e}_z$.curl curl, we get:

$$\frac{1}{p_{r_1}}\frac{\partial}{\partial t}\nabla^2 w - (1-nF)\nabla^4 w - \frac{2d^{*2}\rho\Omega w}{\boldsymbol{\mu}}\nabla^2 w = R_a\nabla_H^2 T - R_n\nabla_H^2\varphi - Q\,\frac{\partial^2 w}{\partial z^2} \tag{25}$$

where $\nabla_H^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ is the two dimensional Laplacian operator on horizontal plane.

3. Normal mode observation

On analysing the disturbances in to normal modes and assuming that the perturbed quantities are of the form:

$$[w, T, \varphi] = [W(z), T(z), \varphi(z)]\exp(ik_x x + ik_y y + nt) \tag{26}$$

Where k_x and k_y are wave numbers in x and y directions respectively, while *n* is growth rate of disturbances.

Using eq. (26), eq.(21),(22), and (25) become:

$$W - \frac{N_A}{L_e}(D^2 - a^2)T - \left[\frac{1}{L_e}(D^2 - a^2) - n\right]\varphi = 0 \tag{27}$$

$$W + \left[(D^2 - a^2) - n + \frac{N_B}{L_e}D - \frac{2N_A N_B}{L_e}D\right]T - \frac{N_B}{L_e}D\varphi = 0 \tag{28}$$

$$\left[(D^2 - a^2)\frac{n}{p_{r_1}} - (1-nF)(D^2-a^2)^2 + QD^2 - \left(\frac{2d^{*2}\Omega}{\upsilon}\right)(D^2 - a^2)\right]W + a^2 R_a T - a^2 R_n\varphi = 0 \;\ldots. \tag{29}$$

Where $D = \frac{d}{dz}$ and $a = \sqrt{{k_x}^2 + {k_y}^2}$ is the dimensionless the resultant wave number. The boundary conditions of the problem in view of normal mode are written as

$$W = 0, D^2W = 0,\ T = 0, \varphi = 0 \text{ at } z = 0 \text{ and } W = 0, D^2W = 0,\ T = 0,\ \varphi = 0 \text{ at } z = 1 \quad (30)$$

4. Linear Stability Observation

Consider the solution in the form $w\,, T\,, \varphi$ is given as:

$w = w_0 \sin \pi z\,, T = T_0 \sin \pi z\ , \varphi = \varphi_0 \sin \pi z$

Equations (27),(28) and (29) reduced as

$$\left[\frac{n}{p_{r_1}} J + (1 - nF)J^2 + Q(J - a^2) - \sqrt{T_A}\, J\right] w_0 - a^2 R_a T_0 + a^2 R_n \varphi_0 = 0 \quad (31)$$

$$w_0 + \frac{N_A}{L_e} J T_0 + \left[\frac{1}{L_e} J + n\right] \varphi_0 = 0 \quad (32)$$

$$w_0 - (J + n)T_0 = 0 \quad (33)$$

From equation (32) & (33), we get

$$\left[(J + n) + \frac{N_A}{L_e} J\right] T_0 + \left(\frac{1}{L_e} J + n\right) \varphi_0 = 0 \quad (34)$$

From equation (31),(33) & (34), we get

$$R_a = \frac{1}{a^2}\left[\left\{(1 - nF)J + \frac{n}{p_{r_1}}\right\} J + Q(J - a^2) - \sqrt{T_A}\, J\right](J + n) - \frac{\left\{(J + n) + \frac{N_a}{L_e} J\right\}}{\frac{1}{L_e} J + n} R_n \quad (35)$$

where $J = \pi^2 + a^2$

For neutral stability, the real part of n is zero. Hence, on putting $n = i\,\omega$, (ω is the real and dimensionless frequency of oscillation) in eq.(35), we get:

$$R_a = \Delta_1 + i\,\omega\,\Delta_2 \quad (36)$$

where

$$\Delta_1 = \frac{J}{a^2}\left[J^2 + Q(J - a^2) - \frac{\omega^2}{p_{r_1}} + \omega^2 F J - \sqrt{T_A}\, J\right] - \frac{1}{\left\{\left(\frac{J}{L_e}\right)^2 + \omega^2\right\}}\left[\frac{J^2}{{L_e}^2}\,(L_e + N_a) + \omega^2\right] R_n \quad (37)$$

and imaginary part

$$\Delta_2 = \frac{1}{a^2}\left[\left\{1 - JF + \frac{1}{p_{r_1}}\right\} J^2 + Q(J - a^2) - \sqrt{T_A}\, J\right] - \frac{\left[\frac{J}{L_e} - J\left(1 + \frac{N_A}{L_e}\right)\right]}{\left\{\left(\frac{J}{L_e}\right)^2 + \omega^2\right\}} R_n \quad (38)$$

R_a will be real since it is a physical quantity Hence, it follow from Eq.(36) that either $\omega = 0$ (exchange of stability, steady state) or $\Delta_2 = 0$ ($\omega \neq 0$ overstability or oscillatory onset).

5. Stationary Deportation

When the stability occurs in as stationary convection, the marginal state will be characterized by $\omega = 0$. the Eq.(38) reduces as:

$$(R_a)_s = \frac{(\pi^2 + a^2)}{a^2}\left[(\pi^2 + a^2)^2 + \pi^2 Q - \sqrt{T_A}(\pi^2 + a^2)\right] - (L_e + N_A)R_n \quad (39)$$

Here R_a is independent of both the prandtl numbers and the parameters containing the Brownian effects and the thermophoretic effects and presented in the thermal energy equation and the conversation equation for nano particles.

Take $x = \frac{a^2}{\pi^2}$ in Eq. (39), then we have

$$(R_a)_s = \frac{\pi^2(1+x)}{x}\left[\pi^2(1 + x)^2 + Q - \sqrt{T_A}(1 + x)\right] - (L_e + N_A)R_n \quad (40)$$

To study the effects of Lewis number L_e, modified diffusivity ratio N_A, and nano particles Rayleigh number R_n , magnetic field and rotation on stationary convection. We examine the nature of

$\frac{\partial R_a}{\partial L_e}$, $\frac{\partial R_a}{\partial N_A}$, $\frac{\partial R_a}{\partial R_n}$, $\frac{\partial R_a}{\partial Q}$, $\frac{\partial R_a}{\partial T_A}$, analytically.

From eq. (40)

$\frac{\partial R_a}{\partial L_e} < 0$, $\frac{\partial R_a}{\partial N_A} < 0$, $\frac{\partial R_a}{\partial R_n} < 0$, $\frac{\partial R_a}{\partial Q} > 0$, $\frac{\partial R_a}{\partial T_A} < 0$

It implies that for stationary convection Lewis number, modified diffusivity ratio, and nano particle Rayleigh number and rotation have destabilizing effect whenever magnetic field has stabilizing effect on the fluid layer.

6. Results and discussion

Hydromagnetic Instability of visco-elastic Walter's (modal B′) nanofluid layer heated from below under the effect of rotation is investigated under realistic boundary conditions.

Figure 1 represents the variation of stationary Rayleigh number with Lewis number L_e for different values of R_n . The stationary Rayleigh number R_a is plotted against Lewis number for fixed values of $N_A = 5, Q = 5, L_e = 10$ and $R_n = 10, 20, 30$. The Rayleigh number decreases with increases in Lewis number, which shows that Lewis number has destabilizing effect on the stationary deportation.

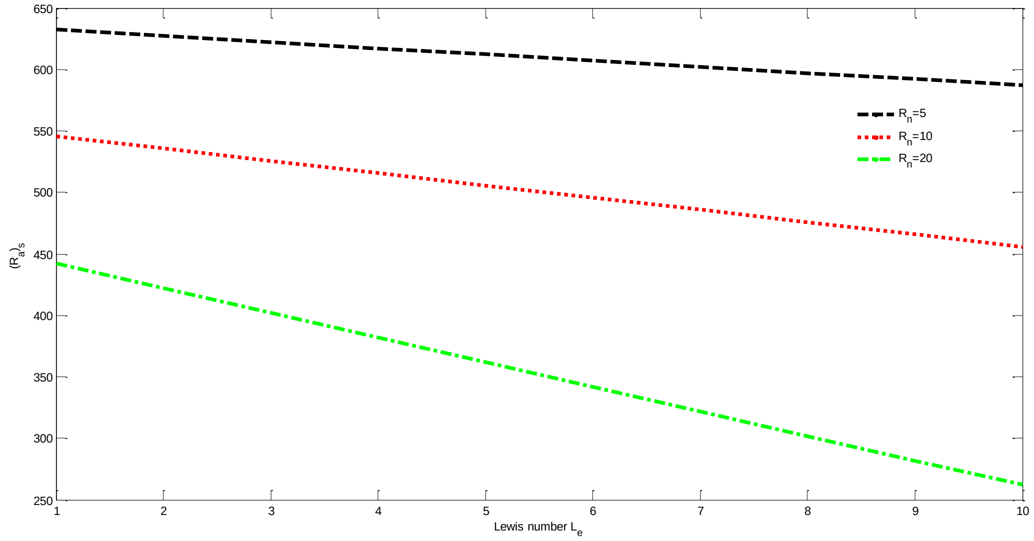

Fig.1: Variations of stationary Rayleigh number with Lewis number

Figure 2 represents the variation of stationary Rayleigh number with Lewis number L_e for different values of R_n . The stationary Rayleigh number R_a is plotted against Lewis number for fixed values of $N_A = 5$, $R_n = 10, L_e = 10$ and $T_A = 10, 20, 30, Q = 5{,}10{,}15$. The Rayleigh number decreases with increases in Lewis number which shows that Lewis number has destabilizing effect on the stationary deportation.

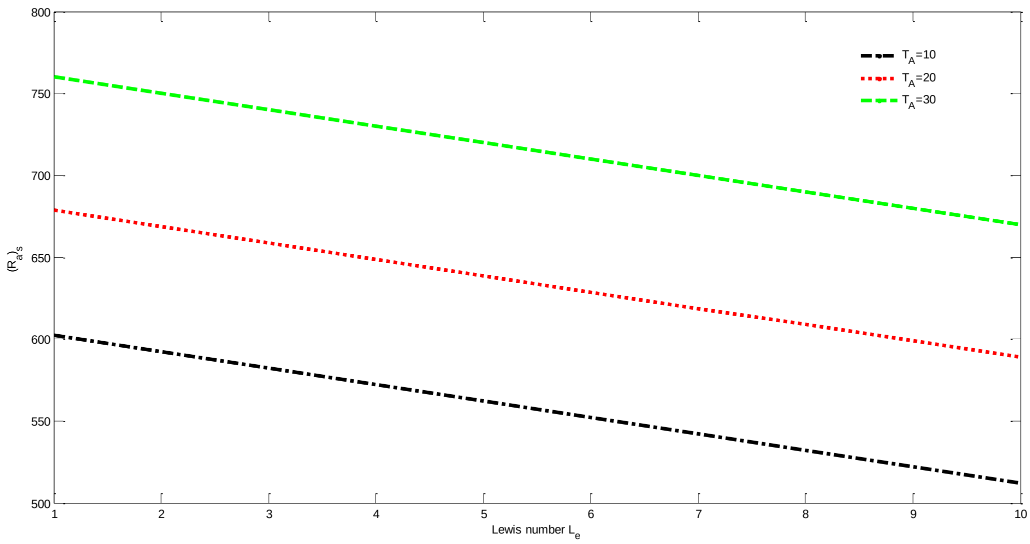

Fig.2: Variations of stationary Rayleigh number with Lewis number

Figure 3 represents the variation of stationary Rayleigh number with modified diffusivity ratio number N_A for different values of Q . The stationary Rayleigh number R_a is plotted against modified diffusivity ratio number for fixed values of $L_e = 5, R_n = 10, N_A = 10$ and $T_A = 10, 20, 30, Q = 5,10,15$. The Rayleigh number decreases with increases in modified diffusivity ratio number which shows that modified diffusivity ratio number has destabilizing effect on the stationary deportation.

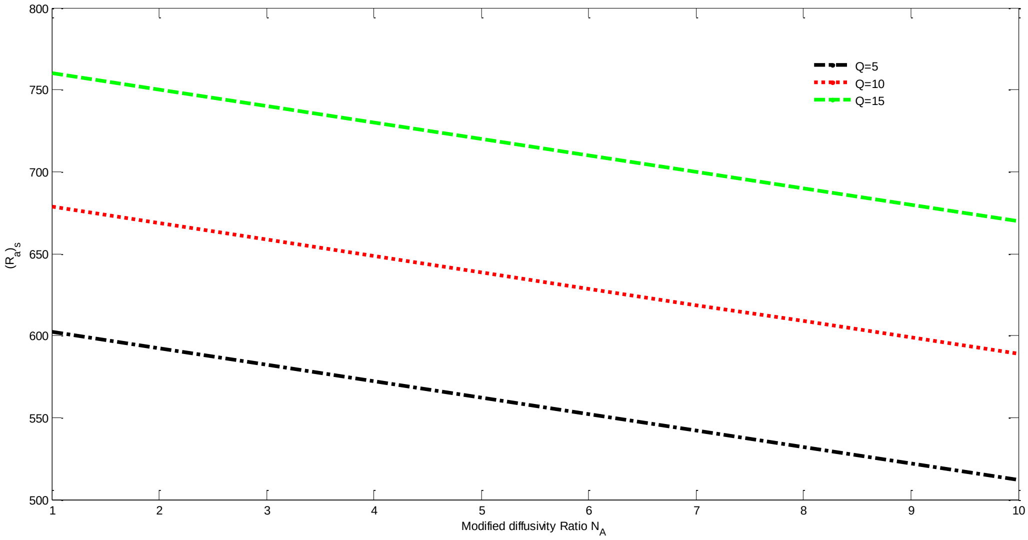

Fig.3: Variations of stationary Rayleigh number with modified diffusivity ratio number

Figure 4 represents the variation of stationary Rayleigh number with modified diffusivity ratio number N_A for different values of L_e . The stationary Rayleigh number R_a is plotted against modified diffusivity ratio number for fixed values of $T_A = 10, R_n = 10, N_A = 10$ and $L_e = 10, 20, 30, Q = 5,10,15$. The Rayleigh number decreases with increases in modified diffusivity ratio number which shows that modified diffusivity ratio number has destabilizing effect on the stationary deportation.

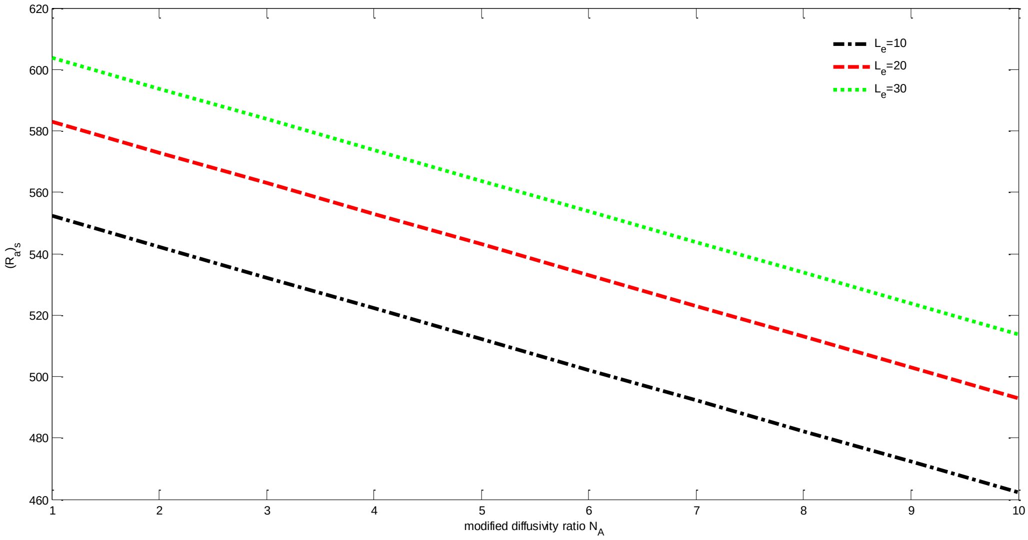

Fig.4: Variations of stationary Rayleigh number with modified diffusivity ratio number

Figure 5 represents the variation of stationary Rayleigh number with nanoparticle Rayleigh number R_n for different values of Q . The stationary Rayleigh number R_a is plotted against nanoparticle Rayleigh number for fixed values of $N_A = 5, R_n = 10, L_e = 10$ and $T_A = 10, 20, 30, Q = 5,10,15$. The Rayleigh number decreases with increases in nanoparticle Rayleigh number which shows that nanoparticle Rayleigh number has destabilizing effect on the stationary deportation.

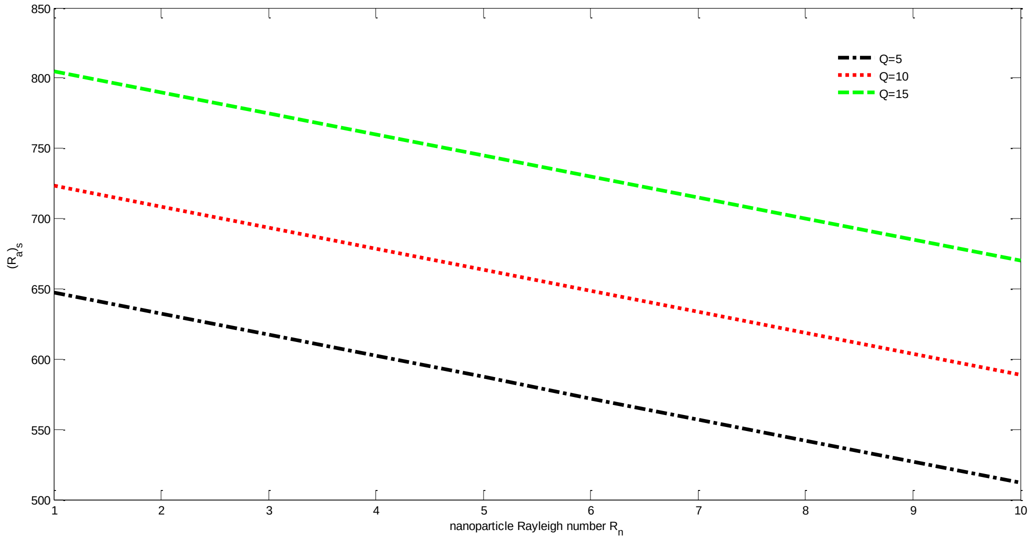

Fig.5: Variations of stationary Rayleigh number with modified nanoparticle Rayleigh number

Figure 6 represents the variation of stationary Rayleigh number with Q for different values of R_n . The stationary Rayleigh number R_a is plotted against Q for fixed values of $N_A = 5,\ Q = 5, L_e = 10$ and $R_n = 5{,}10, 20\ , T_A = 10{,}20{,}30$ The Rayleigh number increases with increases in Q, which shows that Q has stabilizing effect on the stationary deportation.

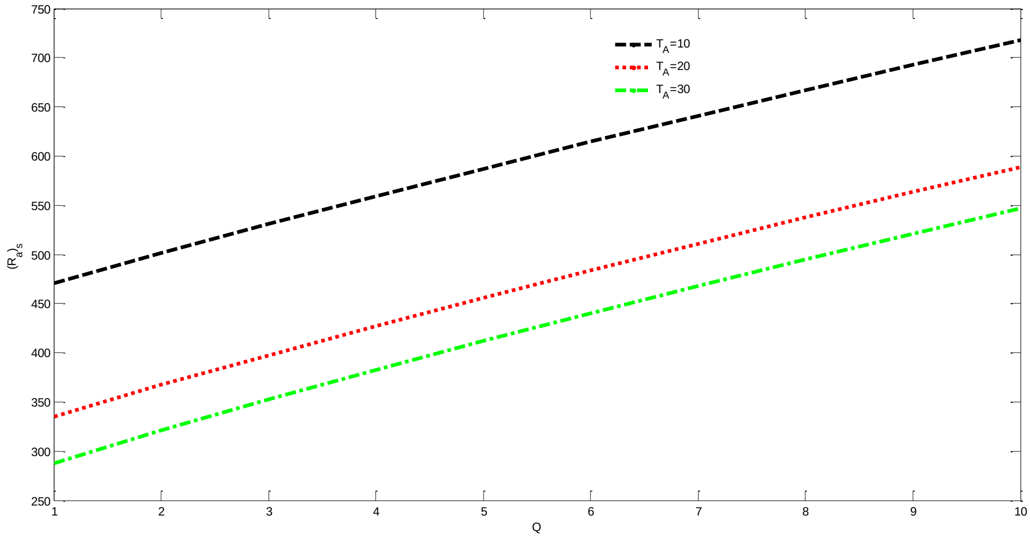

Fig.6: Variations of stationary Rayleigh number with Q

Figure 7 represents the variation of stationary Rayleigh number with for different values of T_A . The stationary Rayleigh number R_a is plotted against T_A for fixed values of $N_A = 5, Q = 5, L_e = 1{,}5{,}10$ and $R_n = 5{,}10, 20\ , T_A = 1{,}2{,}3$ The Rayleigh number decreases with increases in T_A, which shows that T_A has destabilizing effect on the stationary deportation.

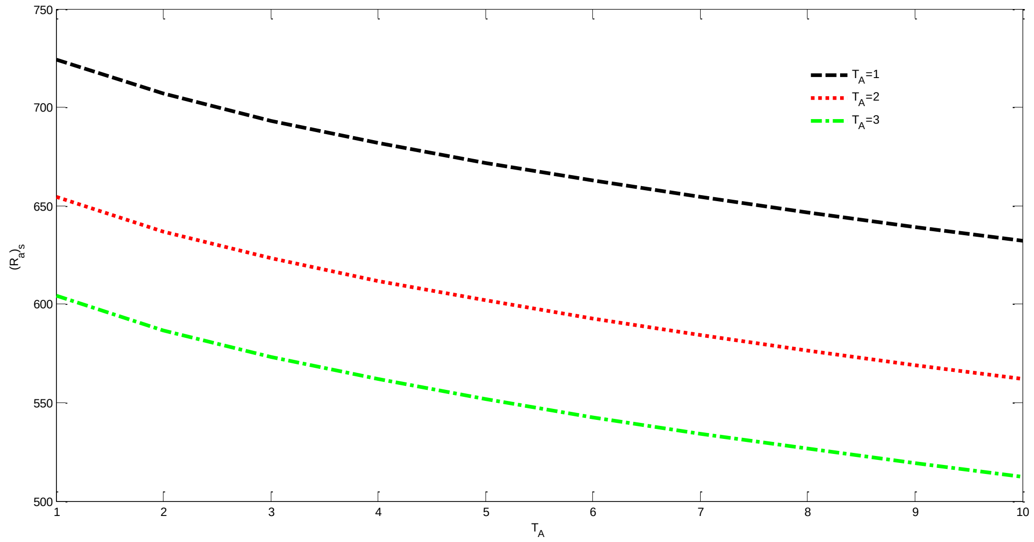

Fig.7: Variations of stationary Rayleigh number with T_A

Figure 8 represents the variation of stationary Rayleigh number with for different values of T_A . The stationary Rayleigh number R_a is plotted against T_A for values of $N_A = 5$, $Q = 5, L_e = 1,5,10$ and $R_n = 5,10,20$, $T_A = 1$ The Rayleigh number decreases with increases in T_A, which shows that T_A has destabilizing effect on the stationary deportation.

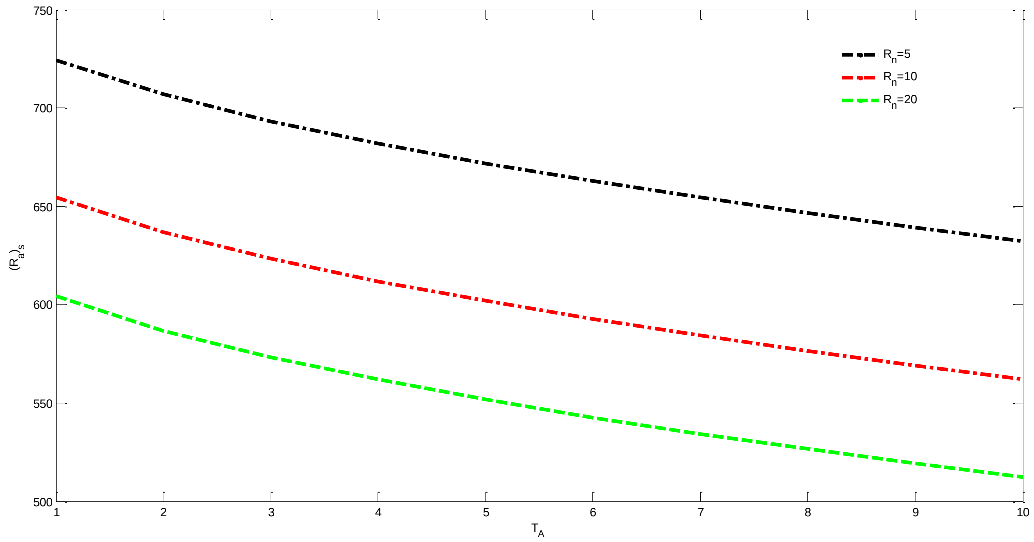

Fig.8: Variations of stationary Rayleigh number with T_A

7. CONCLUSIONS

Hydromagnetic Instability of visco-elastic Walter's (modal B´) nanofluid layer heated from below under the effect of rotation is investigated by using linear instability analysis. The main conclusions from the analysis of this paper are as follows:

(1) For the stationary convection rotation has destabilizing effect on the system.

(2) For the stationary convection magnetic field has stabilizing effect on the system.

(3) Lewis number, modified diffusivity ratio and nano particle Rayleigh number have destabilizing effect on the stationary convection.

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