Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

Research Paper

Unsteady State of Radiating Partially -Ionized Plasma in the Galactic Center

Agriculture

KEYWORDS : Rayleigh ,magnetic field ,Ionized ,neutral ,wave number.

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ABSTRACT

This paper presents unsteady state of a radiating partially-ionized plasma in the galactic center the present of incline magnetic field. is investigated with the influence of collision frequency and radiative flow. We modified chandrasekher, Drazin and Ried method is used in solving the eigenvalue problem with two-dimensional disturbances for the case of stationary convection .Radiation present on the onset of thermal unsteadying is found .to have an unsteady state effect for even a very small radiation parameter of the order α(0.1)concentration gradient on the other hand has a steady state effect on the system. The effect of collision on the onset of stationary cells diminishes for optical thin non-grey plasma-near steady state. This is of relevant and very important in cosmic ray physics as the interaction between the ionized and neutral gas component represents a state which often exists in the universe.

1 INTRODUCTION

In the Occurrences of thermal unsteady state on the onset of radiating ionized plasma in free space, of a fluid heated below and the involving hydro magnetic forces is of immense important in connection with meteorologists, space science ,engineer, industrialist ,environmentalist and in astrophysical phenomena ,geophysical Scientist, ionized gas behaviour, and plasma jets ,equipments in the area such as nuclear power plants, gas turbines and the various propulsion devices for air craft's ,missiles satellite and Space vehicles (Sutton 1959) Post 1956) Shil- Pai 1965).Besides it has a variety of application in MHD Power generator and Hall accelerators(Ram,Singh and Jain,1990), in re-entry problems.(Bestman, Alabraba and Ogulu,1992),in geophysical fluid dynamics, meteorology and engineering. Chamkha et al (2001) studied the Radiation effects on the free convection flow past a semi-finite vertical plate with mass transfer. Muthucumaraswamy and Senthil Kumar (2004) investigated the heat and mass transfer effects on the moving vertical plate in the presence of thermal radiation Prasad et al (2007)Considered the radiation and mass transfer effects on a two -dimensional flow past an impulsively started isothermal vertical plate. The interaction of radiation with hydro magnetic flow has become industrially more prominent in the processes wherever high temperatures occur. Takhar et al (1996) analyzed the radiation effect on MHD free convection flow past a semi-infinite vertical plate using Runge-kutta Merson quadrature. Abd-EL-Naby et al (2003) Studied the radiation effect on MHD unsteady free convection flow over a vertical plate with variable surface temperature. Chaudhary et al (2006) studied the radiation effect with simultaneous thermal and mass diffusion in MHD mixed convection flow from a vertical surface .Ramachandra Prasad et al (2006) Studied the transient radiative hydro magnetic free convection flow past an impulsively started vertical plate with uniform heat and mass flux.

Viscous mechanical dissipation effects are very important in geophysical flow and also in certain industrial operation and are usually characterized by Eckert number. Mahajan and Gebhart (1989) report the influence of viscous heating dissipation in natural convective flows, showing that the heat transfer rates are reduced by an increase in the dissipation parameter. The influence of viscous dissipation and radiation on an unsteady MHD free-convection flow past an infinite heated vertical plate in a porous used Network simulation method[NSM]to study the effects of viscous dissipation and radiation on unsteady MHD free convection flow past a vertical porous plate .An analysis of interaction of radiation and mass transfer on the free convection flow of an electrically conducting dissipative fluid past an impulsively Started isothermal vertical plate with variable with variable surface temperature and concentration was studied by Suneetha et al(2008).The object of this paper is to analyze thermal instability in a radiating partial-ionized plasma in a free convection.

2. NOMACLATURE

M=magnetic field
H_i = magnetic field on the ionic field
H_n = magnetic field strength.
p=pressure
θ =temperature
C= solute concentration

Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

ρ = fluid density
μ = coefficient of viscosity.
D_m = solute diffusion coefficient
β = Thermal coefficient of expansion for temperature
ν = kinematic coefficient
κ = thermal diffusivity.
η = electrical resistivity
α'=solute concentration
δ = radiation absorption coefficient
$\mathcal{X}, \mathcal{Y}, \mathcal{Z}$=cartesian co -ordinate
g=gravity.
$\mathcal{U}, \mathcal{V}, \mathcal{W}$= velocity component.
i= ionized species
n=neutral species
θ_0 = undisturbed temperature.
B=Planck's function
ξ_i = frequency of ionize species
$\bar{\xi}_\iota$=average frequency
a=wave number
ϱ = density variation
d = unit length.
c = velocity of light
R_c =Modified critical Rayliegh number
α = Radiation
ξ_n =frequency of neutral species

3. MATHEMATICAL FORMULATION

In the analysis of exact consequence of radiative transfer in a fluid requires a formulation in terms of integro-differential equations .Solution of equations is complex(Spiegel 1965,) Opara and Bestman 1988) Approximation theories have, been developed that permit a formulation involving only differential equations .One such theory expresses radiation for optically thin non grey gas a differential approximation of variable space co-ordinate .Cogley, Vincenti and Gilles (1968) These theories where originally developed for astrophysical studies and where later employed in neutron transport theory. Although the usual formulation of the problem is well known its modification for radiative terms is not. We therefore consider the flow of a two-component plasma model, using the subscripts i and n to designate ion and neutral particles. The problem as formulated by Sharman and Sunil (1992), is then modified by the radiative term thus.

$$\nabla . q = (\theta - \theta_\infty)\alpha^2$$

$$\alpha^2 = 4 \int_0^\infty (\delta \upsilon \frac{2B}{2\theta})_0 \, d\upsilon$$

B is the Planck's function,δ is the radiation absorption coefficient and υ is the frequency, and θ is the temperature. The equations expressing the continuity ,momentum, heat and solute mass concentration acted on by a uniform vertical magnetic field H$(0,0,$H) and gravity g(0,0,-g) are

$$\nabla . V_i = 0$$

$$\nabla . H_i = 0 \qquad (1)$$

$$(\frac{\partial W_i}{\partial t} + \mathcal{U}_i \frac{\partial W_i}{\partial x} + \mathcal{V}_i \frac{\partial W_i}{\partial y} + \mathcal{W}_i \frac{\partial W_i}{\partial z}) - \frac{\mu}{4\pi\rho_i}(H_x \frac{\partial H_z}{\partial x} + H_y \frac{\partial H_z}{\partial y} + H_z \frac{\partial H_z}{\partial z})$$

$$=\frac{\partial}{\partial z}\frac{(\rho-\rho_0)}{\rho_0}+\frac{\mu}{\rho_0}\left(\frac{\partial^2 W_i}{\partial x^2}+\frac{\partial^2 W_i}{\partial y^2}+\frac{\partial^2 W_i}{\partial z^2}\right)$$

$$-g\beta(\theta-\theta_0)-\frac{\mu}{\rho_0}\kappa(w_i)-g\alpha'(C-C_0)+\frac{fc}{v}(w_n-w_i). \quad (2)$$

$$\left(\frac{\partial H_z}{\partial t}+\mathcal{U}_i\frac{\partial H_z}{\partial x}+\mathcal{V}_i\frac{\partial H_z}{\partial y}+\mathcal{W}_i\frac{\partial H_z}{\partial z}\right)=\left(H_x\frac{\partial W_i}{\partial x}+H_y\frac{\partial W_i}{\partial y}+H_z\frac{\partial W_i}{\partial z}\right)+\eta\nabla^2 H_z \quad (3)$$

$$\left(\frac{\partial\theta}{\partial t}+\mathcal{U}_i\frac{\partial\theta}{\partial x}+\mathcal{V}_i\frac{\partial\theta}{\partial y}+\mathcal{W}_i\frac{\partial\theta}{\partial z}\right)=\kappa\nabla^2\theta-q\alpha\nabla.q \quad (4)$$

and

$$\left(\frac{\partial C}{\partial t}+\mathcal{U}_i\frac{\partial C}{\partial x}+\mathcal{V}_i\frac{\partial C}{\partial y}+\mathcal{W}_i\frac{\partial C}{\partial z}\right)=D_m\nabla^2 C \quad (5)$$

for ionized components

In consequence to the writing of equations 1,2,3,4 and 5 above the Boussinesq approximation has been used. Similarly, for the neutral components we have

$$\mathcal{V}_{n\alpha}\nabla.\mathcal{V}_n=0 \quad (6)$$

$$\left(\frac{\partial w_n}{\partial t}+\mathcal{U}_n\frac{\partial w_n}{\partial x}+\mathcal{V}_n\frac{\partial w_n}{\partial y}+\mathcal{W}_n\frac{\partial w_n}{\partial z}\right)=-\frac{\partial}{\partial z}\frac{(p-p_0)}{\rho_0}+\frac{\mu}{\rho_0}\left(\frac{\partial^2 w_n}{\partial x^2}+\frac{\partial^2 w_n}{\partial y^2}+\frac{\partial^2 w_n}{\partial z^2}\right)$$

$$-g\beta(\theta-\theta_0)-\frac{\mu}{\rho_n}\kappa(w_n)-g\alpha'(C-C_0)+\frac{fc}{v}(w_n-w_i), \quad (7)$$

$$\left(\frac{\partial\theta}{\partial t}+\mathcal{U}_n\frac{\partial\theta}{\partial x}+\mathcal{V}_n\frac{\partial\theta}{\partial y}+\mathcal{W}_n\frac{\partial\theta}{\partial z}\right)=\kappa\nabla^2\theta-q\alpha\nabla.q \quad (8)$$

and

$$\left(\frac{\partial C}{\partial t}+\mathcal{U}_n\frac{\partial C}{\partial x}+\mathcal{V}_n\frac{\partial C}{\partial y}+\mathcal{W}_n\frac{\partial C}{\partial z}\right)=D_m\nabla^2 C \quad (9)$$

$$\rho=\rho_0[1-\beta(\theta-\theta_0)+\alpha'(C-C_0)], \quad (10)$$

where the suffix zero refers to values at the reference level $z=0$. The temperatures and solute concentration at the bottom surface $z=0$ are θ_0, C_0 and at the upper surface $z=d$ are C,θ we have also taken the Cartesian coordinates($\mathcal{X},\mathcal{Y},\mathcal{Z}$) with the origin on the lower boundary$z=0$ and the z-axis perpendicular to it along the vertical (a) In the equation of motion for the neutral component, there will be an equal and opposite term to that in the equation of motion.(b)for the ionized component. The steady state solution is

$$\mathcal{V}(\mathcal{X},\mathcal{Y}.\mathcal{Z})=0 \quad (11)$$

$$\theta=\theta_0-\beta z \quad (11a)$$

$$C=C_0-\beta' z \quad \text{and}$$

$$\rho=\rho_0(1+\beta z-\beta' z)$$

where $\beta$and$\beta'$are the adverse temperature and concentration gradient considering a small perturbation on the steady state. Following the argument of Chandrasekhar (1981) and Bestman and Opara (1990) the liberalized perturbation equation become

Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

$$\frac{\partial\theta}{\partial t} = \kappa\nabla^2\theta_i + \beta w_i - \delta^2 \quad (12)$$

$$\frac{\partial hz_i}{\partial t} = \eta\nabla^2 hz_i + H_0\frac{\partial w\prime_i}{\partial z} \quad (13)$$

$$\frac{\partial\xi_i}{\partial t} = \eta\nabla^2\xi_i + H_0\frac{\partial\xi_i}{\partial z} \quad (14)$$

$$\frac{\partial\xi_i}{\partial t} = v_i(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2} - \frac{1}{\kappa})\xi_i + \frac{\mu}{4\pi\rho_i}H_0\frac{\partial\xi_i}{\partial z} \quad (15)$$

and

$$\frac{\partial}{\partial t}(\nabla^2 w'_i) = v_i(\frac{\partial^4}{\partial x^4} + \frac{\partial^4}{\partial y^4} + \frac{\partial^4}{\partial z^4} - \frac{1}{\kappa})w'_i + \frac{\mu_i}{4\pi\rho_i}\mathrm{H}_0\frac{\partial}{\partial z}(\nabla^2 hz_i)$$

$$+g\alpha'(\frac{\partial^2 c_i}{\partial x^2} + \frac{\partial^2 c'_i}{\partial y^2}) + g\beta(\frac{\partial^2\theta\prime_,}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}) - \frac{fc}{v_i}(\nabla^2 w'_n - \nabla^2 w_i), \quad 16)$$

where w'_i is the z-component of the velocity of ionized particles $\xi_i$is the component of vorticity and $\overline{\xi_\iota}$ is a factor representing the current density.

4. THE DISTRIBUTION/DISPERSION RELATION

Analyzing disturbances in terms of normal modes and assuming that the perturbation the quantities are of the form

$$W'_i = W_i(z)\exp[i(\kappa_x X + \kappa_y Y) + nt]$$

$$\theta_i = \theta(\mathrm{z})\exp[\mathrm{i}(\kappa_x X + \kappa_y Y) + nt]$$

$$\overline{\xi_\iota} = Z_n(z)\exp\exp[i(\kappa_x \mathrm{X} + \kappa_\mathrm{y}\mathrm{Y}) + \mathrm{nt}] \quad (17)$$

$$\xi_i = X_n(Z)\exp[\exp[i(\kappa_x X + \kappa_y Y) + nt]$$

$$\mathrm{h}Z_i = \kappa(Z)\exp[i(\kappa_x X + \kappa_y Y) + nt]$$

where

$$\overline{\xi_\iota} = (\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}) \quad (18)$$

and

$$\xi_i = (\frac{\partial hy}{\partial x} - \frac{\partial hx}{\partial y}) \quad (19)$$

denote respectively the z-components of vorticity and current density;$\kappa_x$andκ_y are the wave number in the x-and y-directions,$\kappa = (\kappa_x^2 + \kappa_y^2)^{\frac{1}{2}}$ is the resultant wave number and the growth rate. Expressing the coordinate x, y, z in the new unit length d and putting

$$\alpha = \kappa d, \sigma = \frac{nd^2}{v}, \varrho_1 = \frac{v}{k}, \varrho_2 = x = dk^{-\frac{1}{2}}, = \frac{\mu}{\rho}, \xi_c = \frac{fcd}{v}, R = g\beta\beta\frac{d^4}{\kappa v}$$

is the thermal Rayleigh number and the time constant $n = \frac{\partial}{\partial t}$,where D= $\frac{d}{dz}$ while M is the non-dimensional magnetic number, Equations (12),13,14,15,and(16) under usual stability analysis Drazin and Ried (2004) can be written.

$$(D^2 - a^2 - \varrho\sigma - R_1\alpha)\theta_i = -(\frac{\beta d^2}{\kappa})W_i \quad (20)$$

$$(D^2 - a^2 - \varrho_2\sigma)K_i = -(\frac{H_0 d}{\eta})DX_i \quad (21)$$

$$(D^2 - a^2 - \varrho_2\sigma)X_i = -\left(\frac{H_0 d}{\eta}\right)DZ_i \quad (22$$

$$(D^2 - a^2 - X^2 - \sigma)Z_i = (\frac{\mu}{4\pi\rho v}H_0 d)DX_i \times$$

$$(D^2 - a^2)(D^2 - a^2 - x^2 - \xi_i^2 - \sigma)W_i +$$

$$+\xi^2(D^2 - a^2)^2 W_n \quad (23)$$

$$(\frac{H_0 d}{\rho v})D(D - a^2)k_i = (g\frac{\beta d^2}{v})a^2\theta_i \quad (24)$$

for ionized components, and

$$(D^2 - a^2 - \varrho_i\sigma - \varrho_i\alpha)\theta_n = -(\frac{\beta d^2}{K})W_n \quad (25)$$

$$(D^2 - a^2 - \sigma)X_i = 0 \quad (26)$$

and

$$(D^2 - a^2)^2(D^2 - a^2 - x^2 - \xi^2)W_n + \xi_n^2(D^2 - a^2)^2 W_i = (g\frac{\beta d^2}{v})a^2\theta_n \quad (27)$$

for neutral components.

if we eliminate θ, k, X and Z between equations (20-23),assuming the time constant to be zero we get

$$Ra^2 W_i = (D^2 - a^2 - \varrho_i\alpha)(D^2 - a^2)(D^2 - a^2 - x^2 - \xi^2)W_i -$$

$$-MD^2 W_i + \xi_i^2(D^2 - a^2)^2 W_n \quad (28)$$

for ions and

$$Ra^2 W_n = (D^2 - a^2 - \varrho_i\alpha)(D^2 - a^2)(D^2 - a^2 - x^2 - \xi_n^2)W_n +$$

$$+\xi_i^2(D^2 - a^2)^2 W_n \quad (29)$$

for neutrals

Now we consider the case in which the both boundaries are free and adjoining medium is electrically non-conducting .The boundaries are assumed to be perfect conductors of both heat and solute concentrations. The boundary conditions appropriate to the problem ,by use of equation (17), are

$$W = D^2 W = X = DZ = \theta = \xi = 0 \quad (30)$$

and hx, hy, hz are continuous.
The component of magnetic field strength depends only on moving charges and is independent of the medium also the tangential components is zero outside the fluid, we get

$$DK = 0 \qquad (31)$$

on the boundaries. With the boundary condition on equations (30) and (31)
it can be shown that all the even-order derivative of W must vanish for Z= 0 and $Z = 1$.
Hence the proper solution of (28),and (29) characterised the lowest mode is

$$W = W_0 sin\pi Z \qquad (32)$$

where W_0 is constant.
If we substitute equation (32) in to equation (28) and (29),and letting $R_i \approx R_n \approx R$ for two species plasma .we obtain the distribution/dispesion relation.

$$\{[Ra^2 - (\pi^2 + a^2 + \varrho_1\alpha)(\pi^2 + a^2 + x^2 + \xi^2)] \times$$

$$\times [Ra^2 - (\pi^2 + a^2 + \varrho_1\alpha)(\pi^2 + a^2)(\pi^2 + a^2 + x^2 + \xi^2) +$$

$$+(\pi^2 + a^2 + \varrho_1\alpha)\pi^2 M] - \xi^4(\pi^2 + a^2)^4\} \qquad (33)$$

To investigate the effects of radiative term α and coupling frequency ξ also examine the behaviour of the numerical solution (33) on the critical Rayleigh number .dimensionless wave number at a given magnetic field as shown in the table 1 fig 1and table 2 fig 2

Table 1: Variation of dimensionless Wave number with modified Rayleigh number R at varying magnet field

$(M)x \quad 0.5, n \quad 3.112, \alpha \quad 0.1, \varrho_1 \quad 1, \xi \quad 1.5.$

A	R at (M=0) x10^3	R at (M=10) x10^3	R at (M=25) x10^3	R at (M=100) x10^3
0.2	5.624	13.48	31.075	122.149
0.3	2.704	6.135	13.884	54.032
0.4	1.819	3.648	7.873	29.802
0.5	1.509	2.598	5.103	18.155
0.6	1.614	2.144	3.619	11.368
0.7	1.847	2.007	2.756	6.791
0.8	2.229	2.075	2.244	3.316
0.9	2.754	2.307	1.959	0.412
1.0	3.427	2.687	1.846	2.199

Table 2: Variation of dimensionless Wave number with modified Rayleigh number R at varying magnet field (M)

B	R at (M=0) x10^3	R at (M=10) x10^3	R at (M=25) x10^3	R at (M=100) x10^3
0.2	5.624	12.804	30.34	105.186
0.3	2.704	5.806	12.964	51.634
0.4	1.819	3.001	6.405	27.965
0.5	1.569	2.035	4.930	10.886
0.6	1.614	1.983	2.860	9.856
0.7	1.847	1.864	2.094	5.335
0.8	2.229	1.945	3.054	2.865
0.9	2.754	2.045	6.736	0.310
1.0	3.427	2.284	8.565	2.005

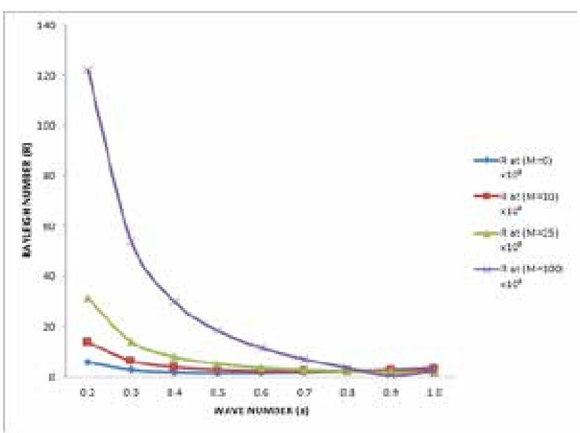

Fig 1:

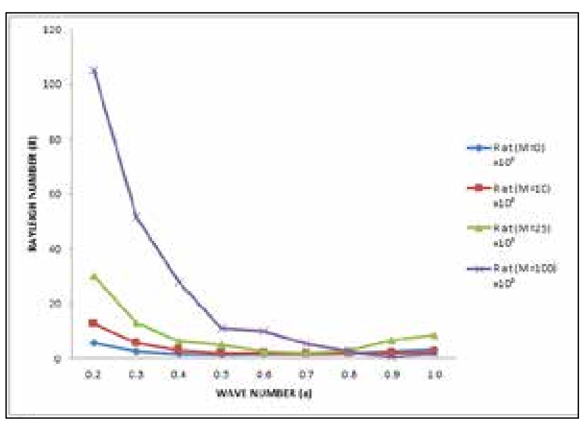

Fig 2:

5. RESULT AND DISCUSION

In the fore going, the formulation and the numerical solution for the effect of radiative and coupling frequency of the problem of eigenvalue with two dimensional -disturbance for the case of stationary convection were presented. By invoking eingenvalue were solved. To comprehend fully the effects of the dependent parameter on the flow state parameters use is made of the following in the numerical computation; on the above table (1), graphs were plotted and pictorially displayed from fig 1 (M=100)x10^3Rayleigh number decrease with increase in wave number assmytoticaly to 0.8 with sharp decrease in gradient 0.9 and small increase shows unsteady respectively,(M=25)x10^3 Rayleigh number decrease in gradient at some point 0.7 and become steady with increase in wave number were intercept at 0.8 along the wave line. also M=100)x10^3,25x10^3,10x10^3,0x10^3all terminate at 1.0.Table 2 graghs where displayed fig 2 when M=100)x10^3 Rayleigh number decrease with in wave number to 0.5 and steady to 0.6 rayleigh number also the wave number.and intercept at 0.8 with order ,M=25x10^3,10 x10^3,0x10^3again (M=100)x10^3,10x10^3,0x$10^3$and all terminate at 1.0.when a steady state set in as stationary convection $\alpha = 0$ the equation which expresses the modified Rayliegh number R as a function of dimensionless wave number (α) may be shown analyticaly.But in this study, the numerical solution shows that for very small radiation parameter α of order 0(0.1) in the presence of magnetic field (M) unsteady set thus in Table 1 from the graph M=0 it shows more steady state effect than does M>0.Further more,when the coupling frequency ξ is 1.5 and 1.0 the critical value of the modified Rayliegh number(R_c)change substantially while the crical wavenumber(α_c) is between 0.7and 0.8 and0.8 to 0.9 respectively as the magnetic field (M) varies.the coupling frequency therefore,has unsteading effect the themo plasma in the intergalactic space.When comparing fig 1 and fig 2 we observed that for $\alpha \leq 0$ thereabouts unsteady state is notable as it is in the presence of radiation term.

Acknowledgement.

The author is so greatfull to Ushie Patric O Cross Rivers State University of technology Department of physics calabar, Uti Sampson U. of Union Bank plc, Alagoa K.D of Niger Delta university Department of physics Wilberforce Island Bayelsa state Nigeria.

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