Chapter

Transverse Thermal Instability of Radiative Plasma with FLR Corrections for Star Formation in ISM

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Abstract

Impact of porosity, rotation and finite ion Larmor radius (FLR) corrections on thermal instability of immeasurable homogeneous plasma has been discovered incorporating the effects of radiative heat-loss function and thermal conductivity. The general dispersion relation is carried out with the help of the normal mode analysis scheme taking the suitable linearized perturbation equations of the difficulty. This general dispersion relations is further reduces for rotation axis parallel and perpendicular to the magnetic field. Thermal instability criterion establishes the stability of the medium. Mathematical calculations have been performed to represent the impact of different limitations on the growth rate of thermal instability. It is found that rotation, FLR corrections and medium porosity stabilize the growth rate of the medium in the transverse mode of propagation. Our outcome of the problem explains that the rotation, porosity and FLR corrections affect the dens molecular clouds arrangement and star configuration in interstellar medium.

Keywords: Thermal instability, Rotation, FLR Correction, Radiative heat-loss functions, ISM

1. Introduction

In different research fields of science, now a day's plasma physics have been one of the most important growing areas of research. Also the plasma instabilities are studied from several decades to understand the process of formation of small and big structures in interstellar medium in astronomy and astrophysics. The learning of thermal unsteadiness is suiting fashionable because this is the major development that agreements through outside warming and radiative codling in cosmological plasma environment and in the interstellar medium. The formation of a high amount of cosmological constructions given as interstellar clouds, solar eminences, concentrated organizations in planetary nebulae, etc., can be clarified by resource of thermal unsteadiness. Thermal unsteadiness occurs in an environment that can be developed into colder because of radiation and fluid reduction. Along with this, a reduction of temperature builds the environment unbalanced and directs to the configuration of novel arrangements because of density concentration (Parker [1] & Field [2]). In the unsteadiness, the serious length scale is lesser than that of the other dynamical unsteadiness's such as the Jeans gravitational unsteadiness; i.e., an environment can be develop into thermally unbalanced still if the environment is steady beside the gravitational unsteadiness. So, it is clear that the substantial foundation of slighter-range configurations is because of thermal unsteadiness in spite of the dynamical unsteadiness. While the masses of these contained dense entities are lower than those needed for gravitational reduction, the situation of thermal unsteadiness gets gratify. Certainly, when the gravitational power of originally uniform plasma is comparatively tiny the solar eminences (Tandberg-Hanssen [3]; Priest [4]) and numerous kinds of interstellar clouds (Spitzer [5]; Hollenbach & Thronson [6]; & Burton et al. [7]) are structured because of the procedure of thermal strengthening. Thermal unsteadiness has been studied by several investigators for more than seven decades in astrophysical objects and plasma physics applications (Aggarwal and Talwar [8]; Bora and Talwar [9]; Fukue & Kamaya [10]; Prajapati et al. [11]; Kaothekar et al. [12]; Sharma and Jain [13]; Prajapati et al. [14]). More recently Kaothekar [15] has discussed the thermal instability of partially ionized viscous plasma with Hall effect FLR corrections flowing through porous medium. Thus, we find that a large number of studies are done for magneto-thermal and radiative plasma with different parameters under various assumptions.

In addition to this, the problem of thermal instability of plasma flowing through porous medium has much significance in the learning of large and small astrophysical entities, such as comets, meteorites and interplanetary dust. More over the learning of flow via porous media is of considerable attention because of its diversity of applications in geophysical circumstances, magneto-hydrodynamics (MHD) flows, laboratories, industries and in petroleum and chemical engineering. A large amount of the pioneer work in the field of plasma flow via porous medium is analyzed by Nield and Bejan [16] and Vafai [17]. Many investigators have discussed the importance of porosity in thermal instability with different physical parameters in different plasma environments (Somerton & Catton [18]; Poulikakos [19]; Nield & Kuznetsov [20]; Shue [21]; Kumar [22]; Kaothekar & Chhajlani [23]; Nield & Kuznetsov [24]; Kaothekar [25]. More recently Nguyen-Thoi et al. [26] have discussed the magneto-hydrodynamic nano-fluid radiative thermal behavior by means of Darcy law inside a porous media. Thus we see that, porosity of the medium plays a crucial role in instability and stability examinations of the thermally magnetized plasma flowing through porous medium.

Along with this, in current days the significance of FLR in thermal instability and gravitational instability of plasma is important owing to its huge relevance in astrophysics. Many researchers (Jukes [27]; Roberts & Taylor [28]; Rosenbluth et al. [29]; Singh & Hans [30]; Herrnegger [31]; Sharma [32]; Chhonkar & Bhatia [33]; Devlen & Pekunlu [34]; Kaothekar & Chhajlani [35]; Kaothekar et al. [36]; Kaothekar [37]) have discussed the importance of FLR corrections in thermal instability with different parameters. More recently Kaothekar [38] has investigated the problem of Jeans instability of finitely conducting radiative rotating plasma with FLR corrections f lowing through porous medium. Thus it is clear that FLR is a significant restriction in argument of thermal instability and Jeans-gravitational instability.

From the above study we discover that combined influence of the rotation, FLR corrections, radiative heat-loss function, thermal conductivity and porosity on the thermal instability is not taken. Thus remaining in brains the importance of rotation and FLR corrections in formation of astrophysical small and big structures, we attempt to argue the outcomes of rotation, porosity and FLR corrections on thermal instability of plasma with thermal conductivity and radiative heat-loss function.

This paper is organized in following ways. In Section 2 linearized equations are presented. Section 3 contains the dispersion relation which is derived by linearized perturbation equations and discussed mathematically for transverse wave propagation. Section 4 represents the linear growth rate of the dispersion relation in transverse wave propagation and finally Section 5 contains discussion of the presented problem and result.

2. Linearized perturbation equations of the problem

We consider an infinite homogeneous, thermally conducting, radiating, porous plasma with FLR corrections in the presence of magnetic field $\boldsymbol{H}$ (0, 0, H). The perturbation in fluid pressure, density, temperature, velocity, magnetic field and heat-loss function are given as δp, $\delta\rho$, δT, $\boldsymbol{u}(\delta u_x, \delta u_y, \delta u_z)$, $\delta\boldsymbol{H}(\delta H_x, \delta H_y, \delta H_z)$, and L respectively. The perturbation circumstances is given as.

$$p = p_0 + \delta p, \rho = \rho_0 + \delta\rho, T = T_0 + \delta T, \boldsymbol{u} = \boldsymbol{u_0} + \delta\boldsymbol{u}, \boldsymbol{H} = \boldsymbol{H_0} + \delta\boldsymbol{H}, \text{and } L = L_0 + L. \tag{1}$$

Suffix '0' represents the initial equilibrium state, which is independent of space and time. L (ρ, T) is the heat-loss function of the material limited of thermal conduction and is in general a cause of the local values of density and temperature Field [2]. The operator (d/dt) is the substantial derivative given as $(d/dt) = (\partial/\partial t + (1/\varepsilon)\ \boldsymbol{u}.\nabla)$. With these effects the linearized perturbation equations of the problem are

$$\left(\frac{1}{\varepsilon}\right)\partial_t \delta\boldsymbol{u} = -\left(\frac{\nabla\delta p}{\rho}\right) - \left(\frac{\nabla\cdot\mathbf{P}}{\rho}\right) + \left(\frac{1}{4\pi\rho}\right)(\nabla\times\delta\boldsymbol{H})\times\boldsymbol{H} + 2(\boldsymbol{u}\times\boldsymbol{\Omega}), \tag{2}$$

$$\varepsilon\,\partial_t\delta\rho + \rho\nabla.\delta\boldsymbol{u} = \mathbf{0}\,, \tag{3}$$

$$\left(\frac{1}{\gamma-1}\right)\partial_t\delta p - \left(\frac{\gamma}{\gamma-1}\right)\left(\frac{p}{\rho}\right)\partial_t\delta\rho + \rho\left[\delta\rho\left(\frac{\partial L}{\partial\rho}\right)_T + \delta T\left(\frac{\partial L}{\partial T}\right)_\rho\right] - \lambda\nabla^2\delta T = 0, \tag{4}$$

$$\left(\frac{\delta p}{p}\right) = \left(\frac{\delta T}{T}\right) + \left(\frac{\delta\rho}{\rho}\right), \tag{5}$$

$$\partial_t\delta\boldsymbol{H} = \left(\frac{1}{\varepsilon}\right)\nabla\times(\boldsymbol{u}\times\boldsymbol{H}), \tag{6}$$

$$\nabla.\delta\boldsymbol{H} = 0, \tag{7}$$

where $(\partial L/\partial T)_\rho$, $(\partial L/\partial\rho)_T$ are the partial derivatives of temperature dependent heat-loss function L_T and density dependent heat-loss function L_ρ respectively. The components of pressure tensor $\mathbf{P}$, considering the finite ion gyration radius for the magnetic field along z-axis as given by Roberts and Taylor [28] are

$$\begin{aligned}
&P_{xx} = -\rho\upsilon_0\left[(\partial\delta u_y/\partial x) + (\partial\delta u_x/\partial y)\right], P_{yy} = \rho\upsilon_0\left[(\partial\delta u_y/\partial x) + (\partial\delta u_x/\partial y)\right],\\
&P_{xy} = P_{yx} = \rho\upsilon_0\left[(\partial\delta u_y/\partial x) - (\partial\delta u_y/\partial y)\right],\\
&P_{xz} = P_{zx} = -2\rho\upsilon_0\left[(\partial\delta u_y/\partial z) + (\partial\delta u_z/\partial y)\right],\\
&P_{yz} = P_{zy} = 2\rho\upsilon_0[(\partial\delta u_z/\partial x) + (\partial\delta u_x/\partial z)],\ \ P_{zz} = 0.
\end{aligned} \tag{8}$$

The parameter υ_0 has the dimensions of the kinematics viscosity and called as magnetic viscosity defined as $\upsilon_0 = \Omega_L R_L^2/4$, where R_L is the ion-Larmor radius and Ω_L is the ion gyration frequency.

We seek plain wave solution of the form

$$\exp\left(i\sigma t + ik_x x + ik_z z\right), \tag{9}$$

where σ is the frequency of harmonic disturbance, k_x and k_z are the wave numbers of the perturbations along x and z axes. Such that

$$k^2 = k_x^2 + k_z^2 \tag{10}$$

The components of Eq. (6) may be given

$$\delta H_x = (iH/\varepsilon\omega)k_z\delta u_x, \quad \delta H_y = (iH/\varepsilon\omega)k_z\delta u_y, \quad \delta H_z = -(iH/\varepsilon\omega)k_x\delta u_x. \tag{11}$$

where $i\sigma = \omega$.

Using Eqs. (4), (5) and (9) we write

$$\delta p = \frac{\left\{ (\gamma-1)\left[TL_T - \rho L_\rho + \left(\frac{\lambda k^2 T}{\rho}\right)\right] + \omega c^2 \right\}}{\left\{ (\gamma-1)\left[\left(\frac{T\rho}{p}\right)L_T + \left(\frac{\lambda k^2 T}{p}\right)\right] + \omega \right\}\delta\rho}, \tag{12}$$

Using Eqs. (3)–(11) in Eq. (2), we may engrave the subsequent algebraic equations for the constituents of Eq. (2)

$$\delta u_x\left[\omega + \left(V^2k^2/\omega\right)\right] + \delta u_y\left[\varepsilon\upsilon_0\left(k_x^2 + 2k_z^2\right) - 2\varepsilon\Omega_z\right] + \varepsilon\left(ik_x/k^2\right)\Omega_T^2\, \mathrm{s} = 0, \tag{13}$$

$$-\delta u_x\left[\varepsilon\upsilon_0\left(k_x^2 + 2k_z^2\right) - 2\Omega_z\right] + \delta u_y\left[\omega + \left(V^2k_z^2/\omega\right)\right] - \delta u_z\left[2\varepsilon(\upsilon_0 k_x k_z + \Omega_x)\right] = 0, \tag{14}$$

$$\delta u_y\left[2\varepsilon(\upsilon_0 k_x k_z + \Omega_x)\right] + \delta u_z\omega + \varepsilon\left(ik_z/k^2\right)\Omega_T^2\, \mathrm{s} = 0. \tag{15}$$

Taking divergence of Eq. (2) and using Eqs. (3)–(11), we obtain as

$$\delta u_x\left[ik_x\left(\frac{V^2k^2}{\varepsilon\,\omega}\right)\right] + \delta u_y\left[i\upsilon_0 k_x\left(k_x^2 + 4k_z^2\right) + 2i(k_z\Omega_x - k_x\Omega_z)\right] - \mathrm{s}\left[\omega^2 + \Omega_T^2\right] = 0, \tag{16}$$

we have made following substitutions $\alpha = (\gamma-1)\left[TL_T - \rho L_\rho + \left(\frac{\lambda k^2 T}{\rho}\right)\right]$, $\beta = (\gamma-1)\left[\left(\frac{T\rho L_T}{p}\right) + \left(\frac{\lambda k^2 T}{p}\right)\right]$, $s = \frac{\delta\rho}{\rho}$, $\Omega_T^2 = \left[\frac{\left(\Omega_I^2 + \omega\Omega_J^2\right)}{(\omega+\beta)}\right]$, $\Omega_J^2 = c^2k^2$, $\Omega_I^2 = k^2\alpha$, $V^2 = \left(\frac{H^2}{4\pi\rho}\right)$, $c = (\gamma p/\rho)^{1/2}$ is the adiabatic velocity of sound in the medium.

3. Dispersion relation

The nontrivial solution of the determinant of the matrix gained from Eqs. (13)–(16) with $\delta u_x, \delta u_y, \delta u_z, s$ having various coefficients that should disappear is to give the subsequent dispersion relation

$$\begin{aligned}&\left(\omega^2+\Omega_T^2\right)\left[\omega+\left(V^2k^2/\omega\right)\right]\left\{\omega\left[\omega+\left(V^2k_z^2/\omega\right)\right]+4\varepsilon^2(v_0k_xk_z+\Omega_x)^2\right\}-\left(2\varepsilon^2\Omega_T^2/k^2\right)\\&\times(v_0k_xk_z+\Omega_x)\left[\omega+\left(V^2k^2/\omega\right)\right]\left[v_0k_xk_z\left(k_x^2+4k_z^2\right)+2\left(k_z^2\Omega_x-k_xk_z\Omega_z\right)\right]\\&+\omega\left[\varepsilon v_0\left(k_x^2+2k_z^2\right)-2\varepsilon\Omega_z\right]^2\left(\omega^2+\Omega_T^2\right)+\left(2\varepsilon k_xk_zV^2/\omega\right)\Omega_T^2(v_0k_xk_z+\Omega_x)\\&\times\left[\varepsilon v_0\left(k_x^2+2k_z^2\right)-2\varepsilon\Omega_z\right]-\omega\left(\varepsilon\Omega_T^2/k^2\right)\left[\varepsilon v_0\left(k_x^2+2k_z^2\right)-2\varepsilon\Omega_z\right]\\&\times\left[v_0k_x^2\left(k_x^2+4k_z^2\right)+2\left(k_xk_z\Omega_x-k_x^2\Omega_z\right)\right]-\omega\left[\omega+\left(V^2k_z^2/\omega\right)\right]\left(V^2k_x^2/\omega\right)\Omega_T^2\\&-\left(4\varepsilon^2k_x^2V^2/\omega\right)\Omega_T^2(v_0k_xk_z+\Omega_x)^2=0.\end{aligned}\tag{17}$$

The dispersion relation (17) demonstrates the jointed influence of rotation, FLR corrections, radiative heat-loss function, thermal conductivity and porosity on the thermal instability of homogeneous plasma flowing through porous medium. The above dispersion relation is long and to learn the consequence of all parameter we now diminish the dispersion relation (17) for transverse mode of transmission.

4. Conversation of the dispersion relation

4.1 Transverse mode of transmission (K⊥B)

In this situation the perturbations are in use to be vertical to the path of the magnetic field (*i.e.* $k_x=k,\ k_z=0$). The dispersion relation (17) reduces to

$$\begin{aligned}&\left(\omega^2+\Omega_T^2\right)\left\{\left[\omega+\left(V^2k^2/\omega\right)\right]\left(\omega^2+4\varepsilon^2\Omega_x^2\right)+\omega\left(\varepsilon v_0k^2-2\varepsilon\Omega_z\right)^2\right\}\\&\quad-\Omega_T^2\left\{\omega\left[\left(V^2k^2/\omega\right)+\varepsilon^2\left(v_0k^2-2\Omega_z\right)^2\right]+4\varepsilon^2\Omega_x^2\left(V^2k^2/\omega\right)\right\}\\&\quad=0.\end{aligned}\tag{18}$$

This dispersion relation (18) provides the control of rotation, FLR corrections, radiative heat-loss function thermal conductivity and porosity on thermal unsteadiness of plasma for transverse mode of transmission. Now we discuss the dispersion relation (18) for rotation axis parallel and vertical to the magnetic field.

4.1.1 Axis of rotation along the magnetic field (Ω||B)

For the case of axis of rotation along the magnetic field, we put $\Omega_x=0$ and $\Omega_z=\Omega$ in dispersion relation (18) which reduces to

$$\omega^3\left\{\omega\left[\omega+\left(V^2k^2/\omega\right)\right]+\varepsilon^2\left(v_0k^2-2\Omega\right)^2+\left(\Omega_I^2+\omega\Omega_J^2\right)/(\omega+\beta)\right\}=0.\tag{19}$$

Eq. (19) has two independent factors. The first factor of Eq. (19) gives $\omega^3=0$, which is a marginal stable mode. The second factor of Eq. (19) gives the following dispersion relation on alternating the values of $\Omega_I^2,\ \Omega_J^2,\alpha$ and β.

$$\begin{aligned}&\omega^3+\left\{\left[(\gamma-1)\left((T\rho L_T/p)+\left(\lambda k^2T/p\right)\right)\right]\right\}\omega^2+\left[4\varepsilon^2\Omega^2+\varepsilon^2v_0^2k^4\right.\\&\left.+V^2k^2+c^2k^2-4\varepsilon^2\Omega v_0k^2\right]\omega+(\gamma-1)\left[(T\rho L_T/p)+\left(\lambda k^2T/p\right)\right]\\&\times\left(4\varepsilon^2\Omega^2+\varepsilon^2v_0^2k^4+V^2k^2-4\varepsilon^2\Omega v_0k^2\right)+k^2(\gamma-1)\\&\quad\times\left[TL_T-\rho L_\rho+\left(\lambda k^2T/\rho\right)\right]\}\\&\quad=0.\end{aligned}\tag{20}$$

This dispersion relation symbolizes the consequence of direct addition of rotation, FLR corrections, radiative heat-loss function, thermal conductivity and porosity on the thermal unsteadiness of the organization. When constant term of Eq. (20) is less than zero this allows at least one positive real root which converses to the unsteadiness of the organization. The situation of unsteadiness obtained from steady term of Eq. (20) is specified as

$$\left\{k^2\left[TL_T-\rho L_\rho+\left(\frac{\lambda k^2 T}{\rho}\right)\right]+\left[\left(\frac{T\rho L_T}{p}\right)+\left(\frac{\lambda k^2 T}{p}\right)\right]\left(4\varepsilon^2\Omega^2+\varepsilon^2\upsilon_0^2k^4+V^2k^2-4\varepsilon^2\Omega\upsilon_0k^2\right)\right\}<0, \tag{21}$$

Eq. (21) symbolizes the modified form of thermal instability criterion by enclosure of rotation, FLR corrections, radiative heat-loss function and thermal conductivity. From Eq. (21) we conclude that rotation and FLR corrections stabilize the radiative instability.

In nonappearance of FLR corrections ($\upsilon_0=0$) Eq. (20) grows to be

$$\begin{aligned}&\omega^3+\{(\gamma-1)[(T\rho L_T/p)+(\lambda k^2T/p)]\}\,\omega^2+\left[4\varepsilon^2\Omega^2+V^2k^2+c^2k^2\right]\omega\\&+\{k^2(\gamma-1)[TL_T-\rho L_\rho+(\lambda k^2T/\rho)]+(\gamma-1)[(T\rho L_T/p)+(\lambda k^2T/p)]\\&\times\left[V^2k^2+4\varepsilon^2\Omega^2\right]\}=0.\end{aligned} \tag{22}$$

When constant term of Eq. (22) is less than zero this permits at least one positive real root which communicates to the instability of the system. The condition of instability attained from constant term of Eq. (22) is given as

$$\left\{k^2(\gamma-1)\left[TL_T-\rho L_\rho+\left(\frac{\lambda k^2T}{\rho}\right)\right]+(\gamma-1)\left[\left(\frac{T\rho L_T}{p}\right)+\left(\frac{\lambda k^2T}{p}\right)\right]\left[V^2k^2+4\varepsilon^2\Omega^2\right]\right\}<0, \tag{23}$$

The above situation of instability is the changed form of thermal condition by addition of rotation and magnetic field strength. From Eq. (23) we bring to a close that rotation and magnetic field stabilize the radiative instability.

Now Eq. (20) can be written in the following form

$$\begin{aligned}&\omega^3+c_s\left\{k_T+\left(\frac{k^2}{k_\lambda}\right)\right\}\omega^2+c_s^2\left[\frac{4\varepsilon^2\Omega^2}{c_s}+\frac{\varepsilon^2\upsilon_0^2k^4}{c_s}+\frac{V^2k^2}{c_s}+k^2-\frac{4\varepsilon^2\Omega\upsilon_0k^2}{c_s}\right]\omega+c_s^3\left[k_T+\left(\frac{k^2}{k_\lambda}\right)\right]\\&\times\left[\frac{4\varepsilon^2\Omega^2}{c_s}+\frac{\varepsilon^2\upsilon_0^2k^4}{c_s}+\frac{V^2k^2}{c_s}+k^2-\frac{4\varepsilon^2\Omega\upsilon_0k^2}{c_s}\right]+\left(\frac{c_s^3k^2}{\gamma}\right)\left[k_T-k_\rho+\left(\frac{k^2}{k_\lambda}\right)\right]=0.\end{aligned} \tag{24}$$

We have used

$$k_\rho=\left[(\gamma-1)\rho L_\rho\right]/(Rc_sT),\ \ k_T=[(\gamma-1)L_T]/(Rc_s),\ \ k_\lambda=(Rc_s\rho)/[(\gamma-1)\lambda], \tag{25}$$

To investigate the effect of viscosity, porosity, rotation and radiative heat-loss functions on the growth rate of thermal instability, we solve Eq. (24) numerically. Therefore Eq. (24) can be written in non-dimensional form with the help of following dimension-less quantities as given in Field [2]

$$\omega^*=\omega/k_\rho c_s,\ \ \Omega^*=\Omega k_\rho/c_s,\ \ \ k^*=k/k_\rho,\ \ \ k_\lambda^*=k_\rho/k_\lambda,\ \ k_T^*=k_T/k_\rho, \tag{26}$$

In astrophysical circumstances, instability of the organization is one of the most significant reasons of arrangement of entities. So we learn the consequences of medium porosity ε, rotation Ω^*, and FLR corrections v_0^* on the growth rate of unstable mode. Using Eq. (26), we write Eq. (24) in non-dimensional form as

$$\omega^{*3} + \left(k_T^* + k_\lambda^{*2}\right)\omega^{*2} + \left[4\varepsilon^2\Omega^{*2} + \varepsilon^2 v_0^{*2}k^{*4} + V^{*2}k^{*2} + k^{*2} - 4\varepsilon^2\Omega^* v_0^* k^{*2}\right]\omega^* + \left(4\varepsilon^2\Omega^{*2} + \varepsilon^2 v_0^{*2}k^{*4} + V^{*2}k^{*2} - 4\varepsilon^2\Omega^* v_0^* k^{*2}\right)\left(k_T^* + k_\lambda^{*2}\right) + \left(k^{*2}/\gamma\right)\left[k_T^* - 1 + k_\lambda^* k^{*2}\right] = 0. \tag{27}$$

Mathematical computations were executed to decide the roots of (ω^*) as a function of wave number (k^*) for moderately a few values of dissimilar parameters occupied captivating $\gamma = 5/3$. Out of three modes, only one mode is unstable for which the computations are at presented in **Figures 1–5**, where the growth rate ω^* has been sketched versus the wave number k^* to display the reliance of the growth rate on the dissimilar substantial limitations such as porosity, rotation and FLR corrections. It is clear from **Figure 1** that the max out rate of the growth rate reduces with augment in the rate of medium porosity. Thus the consequence of medium porosity is stabilizing on the growth rate of the environment. From **Figure 2** we see that the growth rate diminishes with augment in the value of rotation. Thus it is bring to a close that rotation stabilizes the growth rate of the environment. One can examine from **Figure 3** that the growth rate diminishes with rising FLR corrections. Thus the effect of FLR corrections is stabilizing on the growth rate of the environment. From **Figure 4** it is clear that growth rate diminishes on raising the value of

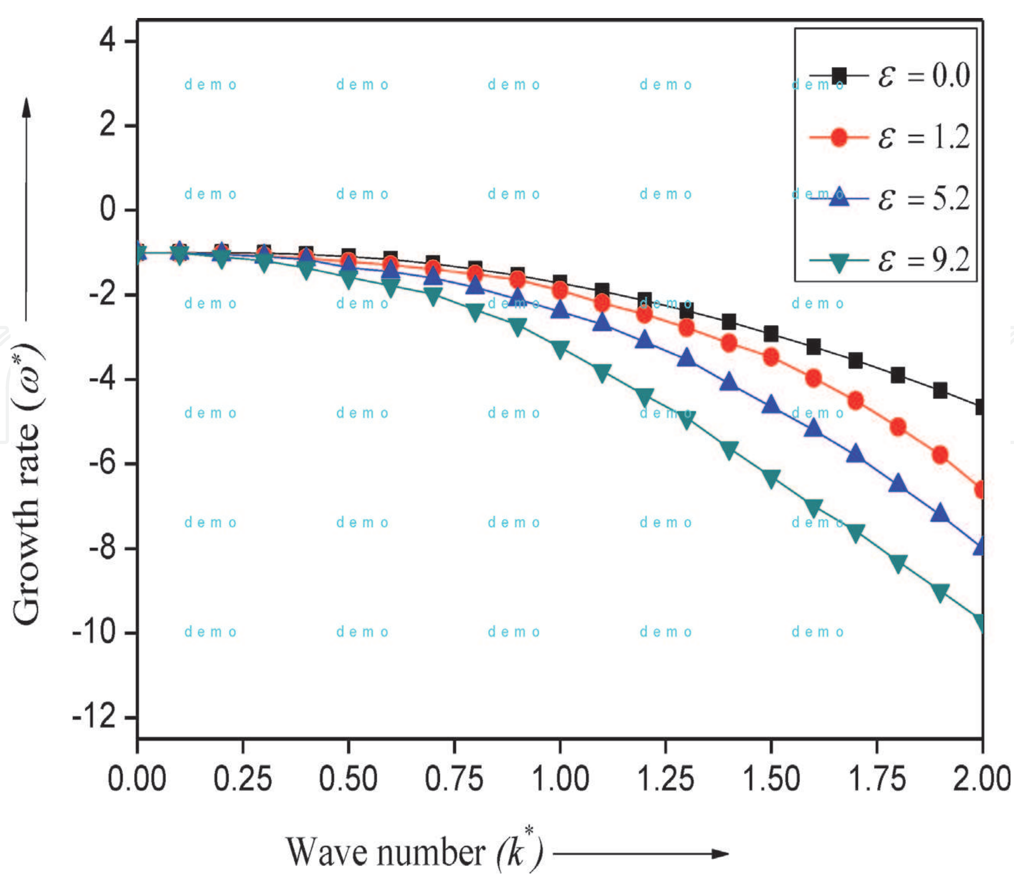

Figure 1.
Growth rate (ω^*) against wave number k^* for four values of parameter ε keeping the other parameters fixed $K_T{}^* = 1$, $K_\lambda{}^* = 0$, $V^* = 1$, $\nu_0{}^* = 1$, $\Omega^* = 1.0$.

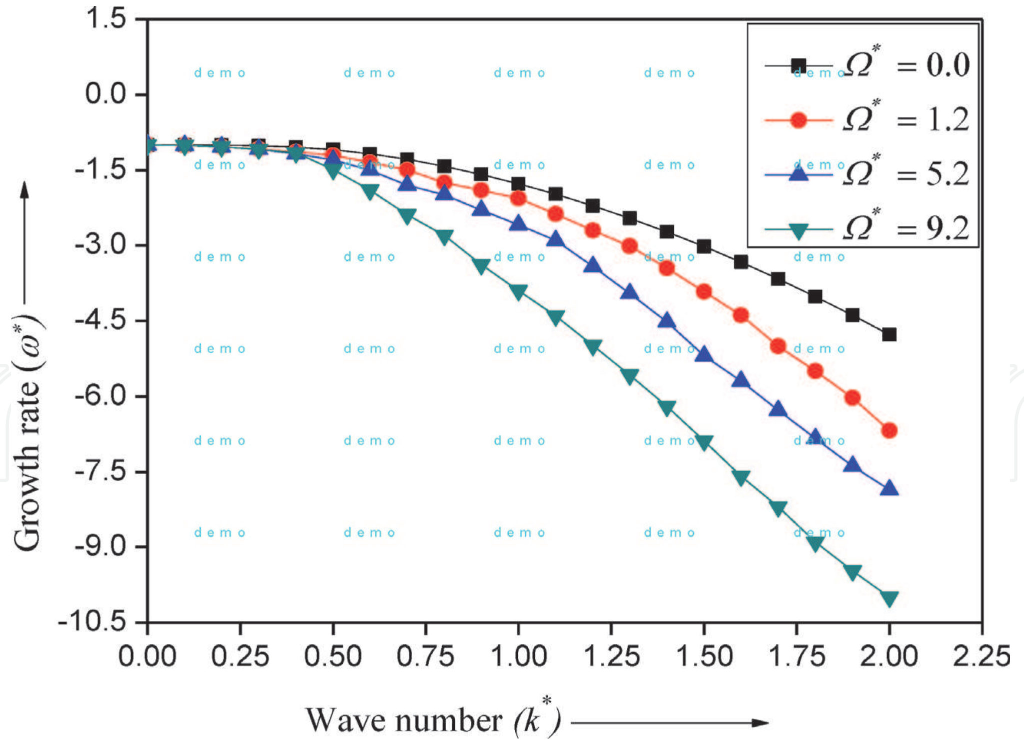

Figure 2.
Growth rate (ω^*) against wave number k^* for four values of parameter Ω^* keeping the other parameters fixed $K_T^* = 1.0$, $K_\lambda{}^* = 0$, $V^* = 1$, $\nu_0{}^* = 1$, $\varepsilon = 1.0$.

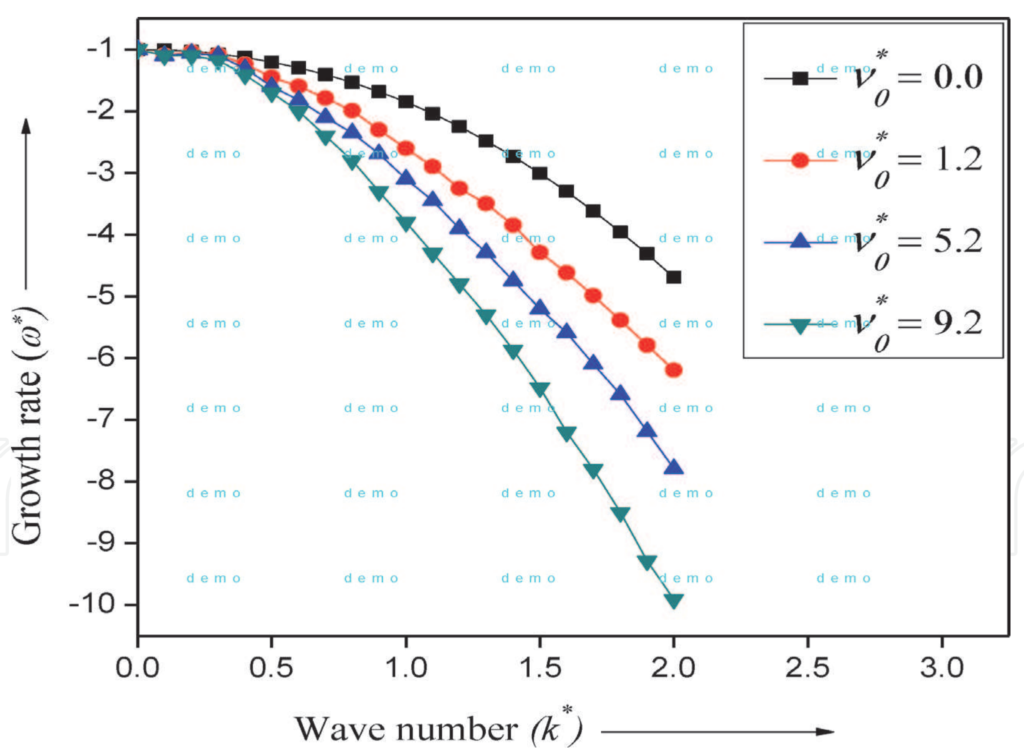

Figure 3.
Growth rate (ω^*) against wave number k^* for four values of parameter $\nu_0{}^*$ keeping the other parameters fixed $K_T^* = 1.0$, $K_\lambda{}^* = 0$, $V^* = 1$, $\Omega^* = 1$, $\varepsilon = 1.0$.

K_T^*. So K_T^* shows stabilizing effect on the growth rate of the environment. One can observe from **Figure 5** that as the value of K_λ^* increases the growth rate of the environment decreases. So it is clear that K_λ^* stabilize the growth rate of the environment.

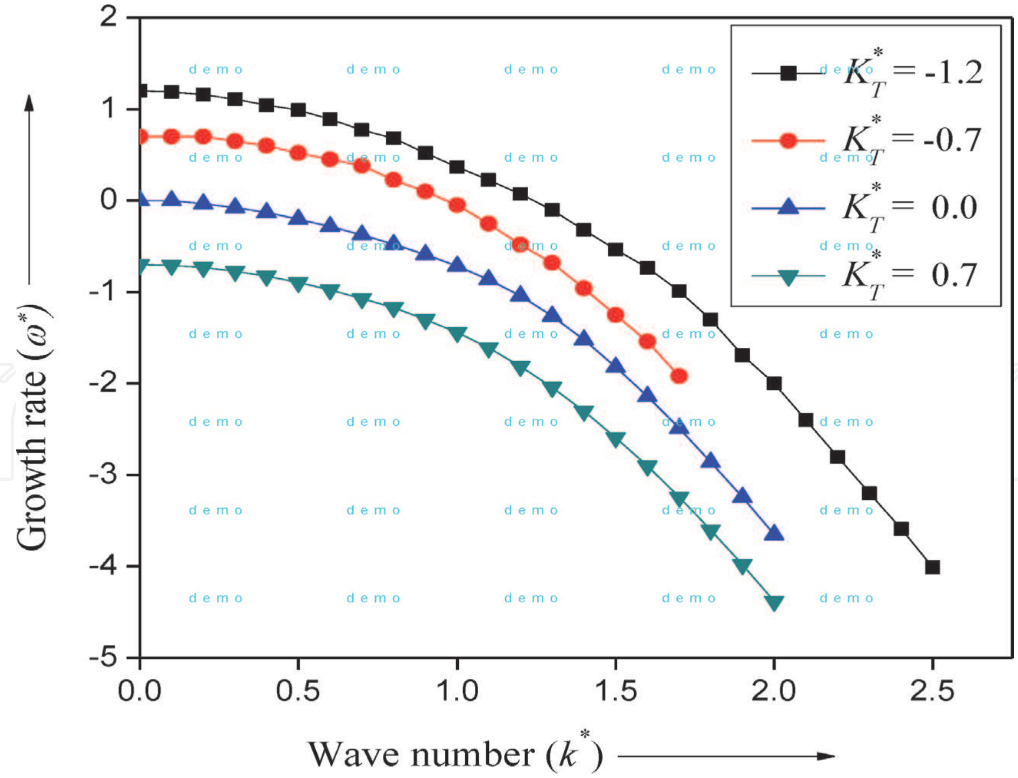

Figure 4.
Growth rate (ω^*) against wave number k^* for four values of parameter K_T^* keeping the other parameters fixed $K_\lambda^* = 1, V^* = 1, \Omega^* = 1, \varepsilon = 1.0$.

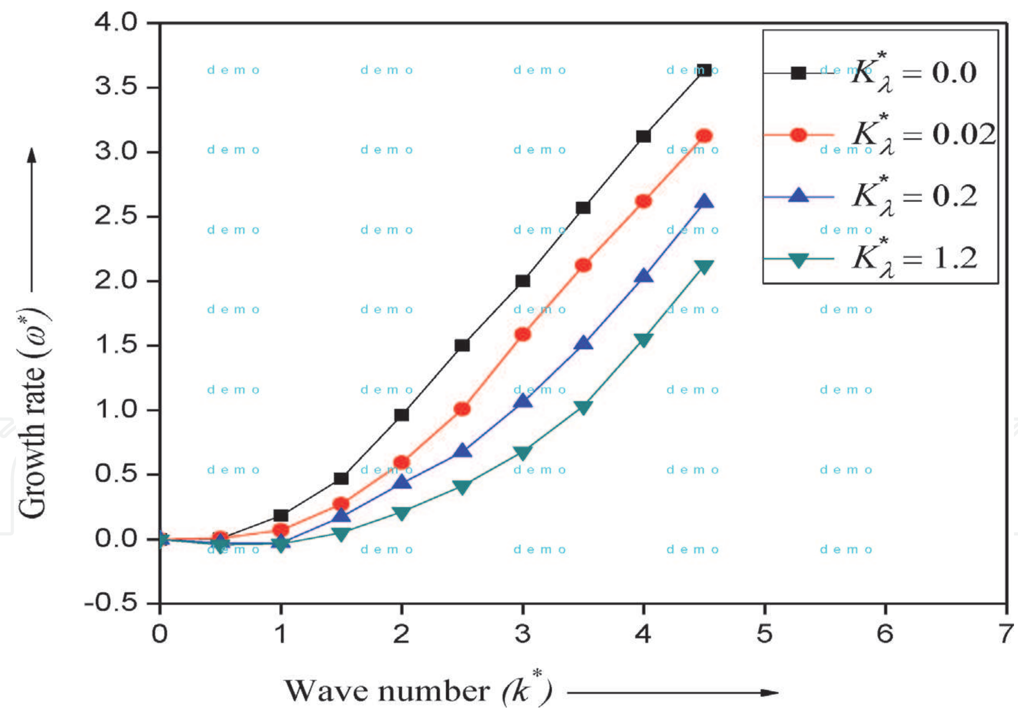

Figure 5.
Growth rate (ω^*) against wave number for four values of parameter K_λ^* keeping the other parameters fixed $K_T^* = 1, V^* = 1, \Omega^* = 1, \varepsilon = 1.0$.

4.1.2 Axis of rotation vertical to the magnetic field ($\Omega \perp B$)

In the case of axis of rotation perpendicular to the magnetic field, we put $\Omega_x = \Omega$ and $\Omega_z = 0$ in the dispersion relation (18) which reduces to

$$\omega\left\{\omega^2\left(\omega^2+4\varepsilon^2\Omega^2+\varepsilon^2 v_0^2 k^4\right)+\left(\omega^2+4\varepsilon^2\Omega^2\right)\left[V^2k^2+\frac{\left(\Omega_I^2+\omega\Omega_J^2\right)}{(\omega+\beta)}\right]\right\}=0. \tag{28}$$

This dispersion relation symbolizes the joint influence of FLR corrections, rotation, porosity magnetic field, radiative heat-loss function and thermal conductivity on the thermal instability of the considered organization. Eq. (28) has two independent factors. The first factor of Eq. (28) gives $\omega = 0$, which is a marginal stable mode. The second factor of Eq. (28) gives the following dispersion relation on replacing the values of Ω_I^2, Ω_J^2, and β.

In nonattendance of rotation ($\Omega = 0$) Eq. (28) becomes

$$\begin{aligned}&\omega^3+\left\{(\gamma-1)\left[\left(\frac{T\rho L_T}{p}\right)+\left(\frac{\lambda k^2 T}{p}\right)\right]\right\}\omega^2\\&\quad+\left[\varepsilon^2 v_0^2 k^4+V^2k^2+c^2k^2\right]\omega+\left\{k^2(\gamma-1)\times\left[TL_T-\rho L_\rho+\left(\frac{\lambda k^2 T}{\rho}\right)\right]\right.\\&\quad\left.+(\gamma-1)\left[\left(\frac{T\rho L_T}{p}\right)+\left(\frac{\lambda k^2 T}{p}\right)\right]\left[\varepsilon^2 v_0^2 k^4+V^2k^2\right]\right\}\\&\quad=0.\end{aligned} \tag{29}$$

The situation of instability acquired from constant term of Eq. (29) is given as

$$\left\{k^2(\gamma-1)\left[TL_T-\rho L_\rho+\left(\frac{\lambda k^2 T}{\rho}\right)\right]+(\gamma-1)\left[\left(\frac{T\rho L_T}{p}\right)+\left(\frac{\lambda k^2 T}{p}\right)\right]\left[\varepsilon^2 v_0^2 k^4+V^2k^2\right]\right\}<0. \tag{30}$$

In present case situation of instability and growth rate of instability both depend on FLR corrections and porosity.

5. Conclusions

In the above present problem we have approved out the consequence of rotation, porosity and FLR corrections on the thermal instability of plasma counting the effects of radiative heat-loss function and thermal conductivity. The general dispersion relation is attained, which is customized due to the attendance of calculated physical limitations. This dispersion relation is condensed for transverse wave propagation to the route of magnetic field, which is additional argued for rotation axis parallel and vertical to the route of magnetic field.

In the situation of transverse wave propagation to the direction of magnetic field with axis of rotation along magnetic field we gained two modes. The first one is a marginal stable mode. The second one represents the thermal mode amended by rotation, porosity, FLR corrections and radiative heat-loss function. It is concluded that the condition of thermal unsteadiness is modified due to the attendance of porosity, rotation, FLR corrections, radiative heat-loss function, and thermal conductivity. For the case of non-FLR medium, it is found that the condition of radiative unsteadiness and expression of critical thermal wave number both are amended due to the occurrence of porosity, rotation, and it explains the stabilizing influence. It is found that for non-FLR the condition of radiative unsteadiness and expression of critical thermal wave number both are amended due to the occurrence of porosity, rotation and magnetic field. It is self-governing of FLR corrections.

In the case of axis of rotation vertical to the magnetic field for transverse wave propagation, we obtained two modes. The first one is a marginal stable mode. The second one symbolizes the impact of porosity, rotation, FLR corrections, radiative heat-loss function and thermal conductivity on thermal unsteadiness of plasma. It is concluded that the condition of unsteadiness is sovereign of porosity, rotation and FLR corrections and it depends on radiative heat-loss function and thermal conductivity. But the growth rate of the organization is exaggerated by the attendance of rotation, porosity and FLR corrections. For the case of non-rotating medium, it is found that condition of radiative unsteadiness is amended by the presence of FLR corrections, porosity and magnetic field, and it demonstrates stabilizing authority.

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