Effect of Rotation and FLR Corrections on Longitudinal Thermal Instability of Finitely Conducting Radiative Porous Plasma in Interstellar Medium (ISM)

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Abstract. The impact of rotation, finite ion Larmor radius (FLR) corrections and porosity on the thermal instability of infinite homogeneous plasma has been discovered incorporating the outcomes of radiative heat-loss function and thermal conductivity. The dispersion relation is obtained by resources of the normal mode analysis method with the assist of suitable linearized perturbation equations of the difficulty. This dispersion relation is supplementary decreases for rotation axis parallel and perpendicular to the magnetic field. Thermal instability condition founded the stability of the system. Arithmetical calculations have been implemented to represent the effect of various constraints on the growth rate of the thermal instability. We find that rotation, FLR corrections and medium porosity stabilize the growth rate of the system in longitudinal mode of propagation. Our outcome demonstrates that the rotation, porosity and FLR corrections influence the dens molecular clouds configuration and star formation in interstellar medium.

Key words: Thermal instability, Rotation, FLR Correction, Radiative heat-loss functions, Flow through porous media, ISM.

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1. Introduction

In the diverse examine fields of physics, with current era plasma physics have been one of the mainly importantly developing regions of investigation. Also the plasma instabilities are revised from quite a lot of decades to recognize the procedure of configuration of small and big compositions in interstellar medium in astronomy and astrophysics. The investigation of thermal instability is becoming well known as the significant cycle manages outside heating and radiative cooling in astrophysical plasma and in the interstellar medium (ISM). The presence of an enormous number of astrophysical structures like interstellar clouds, sun powered prominences, localized structures in planetary nebulae, and so forth, can be made sense of through thermal instability. Thermal instability emerges in a medium that can become cooler because of radiation and fluid contraction. Further, a lessening in the temperature makes the system unstable and prompts the development of new designs because of density condensation (Parker 1953; Field 1965). In this unsteadiness, the basic length scale is more modest than that of the other dynamical instabilities like the Jeans gravitational instability; i.e., a framework can turn out to be thermally temperamental regardless of whether the framework is steady against the gravitational instability. At the point when the masses of such restricted localized dense items are not exactly those expected for gravitational instability, the state of thermal instability gets fulfilled. Numerous specialists have examined the issue of thermal instability with various parameters [Aggarwal & Talwar (1969); Tandberg-Hanssen 1974; Bora & Talwar (1993); Fukue & Kamaya (2007); Shadmehri (2009); Prajapati et al. (2010); Nekrasov (2011); Kaothekar et al. (2012); Nipoti & Posti (2013), Prajapati et al. (2016) and Kaothekar (2018)]. More newly Kaothekar et al. (2023) have explored the problem on thermal instability of astrophysical plasma having impacts of FLR corrections, radiative heat-loss function, porosity and rotation. Thus, we find that a large number of studies are done for thermal instability of plasma with different parameters under various assumptions.

Likewise, the issue of warm shakiness of plasma moving through permeable medium has a lot of significance in the investigation of enormous and little astrophysical items, like comets, shooting stars and interplanetary dust. A large part of the great work in the field of plasma course through porous medium is delaminated by Nield & Bejan (1999) and Vafai (2000). Many investigators have explored the effect of porosity on thermal instability with different parameters [Somerton & Catton (1982); Desavie et al. (2002); Nield & Kuznetsov (2009); Shue (2011); Kaothekar & Chhajlani (2013); Nield & Kuznetsov (2014), Kaothekar (2017), and Nguyen-Thoi et al. (2019)]. More recently Sharma et al. (2023) have discussed the problem on thermal instability of rotating Jeffrey nanofluid in porous media with variable gravity. Thus we observe that, porosity of the medium participates in a decisive function in instability and stability assessments of the thermally magnetized plasma flowing via porous medium.

Alongside this, in current days the meaning of FLR in thermal instability and gravitational instability of plasma is significant attributable to its tremendous importance in astronomy. Many researchers [Jukes1964; Roberts & Taylor 1962; Rosenbluth et al. 1962; Singh & Hans 1965; Herrnegger (1972); Sharma (1974); Chhonkar & Bhatia (1977); Devlen & Pekunlu (2010), Kaothekar & Chhajlani (2012), and Kaothekar et al. (2016)] have scrutinized the stabilizing control of finite ion Larmor radius (FLR) which displays itself in the appearance of magnetic viscosity in the fluid dynamic equations, on the plasma instability. More recently Kaothekar (2021) has discussed the impact of FLR corrections and rotation with radiative heat-loss functions on Jeans gravitational instability of finitely conducting porous plasma. Thus it is obvious that FLR is a noteworthy constraint in discussion of thermal instability and Jeans-gravitational instability.

Thus having in brains the significance of rotation and FLR corrections in arrangement of astrophysical small and big arrangements, we make an effort to discuss the outcome of rotation, porosity and FLR corrections on thermal instability of plasma with thermal conductivity and radiative heat-loss function.

2. Linearized Perturbation Equations

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 state is given as

$$p = p_0 + \delta p,\ \rho = \rho_0 + \delta\rho,\ T = T_0 + \delta T,\ \boldsymbol{u} = \boldsymbol{u}_0 + \delta\boldsymbol{u},\ \boldsymbol{H} = \boldsymbol{H}_0 + \delta\boldsymbol{H} \text{ and } L = L_0 + L. \quad (1)$$

Suffix ‘0’ symbolizes the initial equilibrium state, which is autonomous of space and time.

The linearized perturbation equations of motion for such medium are

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

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

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

$$\frac{\delta p}{p} = \frac{\delta T}{T} + \frac{\delta\rho}{\rho}, \tag{5}$$

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

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

where $\left(\partial L/\partial T\right)_\rho$, $\left(\partial L/\partial \rho\right)_T$ are the partial derived of temperature dependent heat-loss function L_T and density dependent heat-loss function L_ρ respectively. The constituents of pressure tensor **P**, thinking the finite ion gyration radius for the magnetic field along z-axis as given by Roberts and Taylor (1962) are

$$P_{xx} = -\rho\upsilon_0\left(\frac{\partial\delta u_y}{\partial x} + \frac{\partial\delta u_x}{\partial y}\right), P_{yy} = \rho\upsilon_0\left(\frac{\partial\delta u_y}{\partial x} + \frac{\partial\delta u_x}{\partial y}\right),$$

$$P_{xy} = P_{yx} = \rho\upsilon_0\left(\frac{\partial\delta u_x}{\partial x} - \frac{\partial\delta u_y}{\partial y}\right), P_{xz} = P_{zx} = -2\rho\upsilon_0\left(\frac{\partial\delta u_y}{\partial z} + \frac{\partial\delta u_z}{\partial y}\right),$$

$$P_{yz} = P_{zy} = 2\rho\upsilon_0\left(\frac{\partial\delta u_z}{\partial x} + \frac{\partial\delta u_x}{\partial z}\right),\ P_{zz} = 0. \tag{8}$$

The limitation υ_0 has the dimensions of the kinematics viscosity and described 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 equation (7) may be given

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

where $i\sigma = \omega$

By means of equations (5), (6) and (9) we write

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

By means of equations (4)-(12) in equation (3), we may derive the subsequent algebraic equations for the constituents of equation (3)

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

$$-\delta u_x\left[\varepsilon\upsilon_0(k_x^2+2k_z^2)-2\Omega_z\right]+\delta u_y\left[\omega+\frac{V^2k_z^2}{\omega}\right]-\delta u_z\left[2\varepsilon\left(\upsilon_0k_xk_z+\Omega_x\right)\right]=0, \qquad (14)$$

$$\delta u_y\left[\,2\varepsilon\left(\upsilon_0k_xk_z+\Omega_x\right)\right]+\delta u_z\omega+\varepsilon\frac{ik_z}{k^2}\Omega_T^2\,\mathrm{s}=0. \qquad (15)$$

Taking divergence of equation (3) and using equation (4) to (12), we obtain as

$$\delta u_x\left[ik_x\frac{V^2k^2}{\varepsilon\omega}\right]+\delta u_y\left[i\upsilon_0k_x\left(k_x^2+4k_z^2\right)+2i\left(k_z\Omega_x-k_x\Omega_z\right)\right]-\mathrm{s}\left[\omega^2+\Omega_T^2\right]=0 \qquad (16)$$

we have made following substitutions

$$\alpha=(\gamma-1)\left(TL_T-\rho L_\rho+\frac{\lambda k^2T}{\rho}\right),\ \beta=(\gamma-1)\left(\frac{T\rho L_T}{p}+\frac{\lambda k^2T}{p}\right),\ s=\delta\rho/\rho,$$

$\Omega_T^2=\dfrac{\Omega_I^2+\omega\Omega_J^2}{\omega+\beta},\ \Omega_J^2=c^2k^2,\ \Omega_I^2=k^2\alpha,\ V^2=\dfrac{H^2}{4\pi\rho},\ c=(\gamma p/\rho)^{1/2}$ is the adiabatic velocity of sound in the medium. (17)

3. Dispersion Relation

The nontrivial solution of the determinant of the matrix expanded from equations (13)-(16) with $\delta u_x,\delta u_y,\delta u_z,\ s$ having various coefficients that be supposed to vanish is to give the succeeding dispersion relation

$$\left(\omega^2+\Omega_T^2\right)\left[\omega+\frac{V^2k^2}{\omega}\right]\left\{\omega\left[\omega+\frac{V^2k_z^2}{\omega}\right]+4\varepsilon^2\left(\upsilon_0k_xk_z+\Omega_x\right)^2\right\}-\frac{2\varepsilon^2\Omega_T^2}{k^2}\left(\upsilon_0k_xk_z+\Omega_x\right)\left[\omega+\frac{V^2k^2}{\omega}\right]\left[\upsilon_0k_xk_z\right.$$

$$\left.\times\left(k_x^2+4k_z^2\right)+2\left(k_z^2\Omega_x-k_xk_z\Omega_z\right)\right]+\omega\left[\varepsilon\upsilon_0\left(k_x^2+2k_z^2\right)-2\varepsilon\Omega_z\right]^2\left(\omega^2+\Omega_T^2\right)+\frac{2\varepsilon k_xk_zV^2}{\omega}\Omega_T^2\left(\upsilon_0k_xk_z+\Omega_x\right)$$

$$\times\left[\varepsilon\upsilon_0\left(k_x^2+2k_z^2\right)-2\varepsilon\Omega_z\right]-\omega\frac{\varepsilon\Omega_T^2}{k^2}\left[\varepsilon\upsilon_0\left(k_x^2+2k_z^2\right)-2\varepsilon\Omega_z\right]\left[\upsilon_0k_x^2\left(k_x^2+4k_z^2\right)+2\left(k_xk_z\Omega_x\right.\right.$$

$$\left.\left.-k_x^2\Omega_z\right)\right]-\omega\left[\omega+\frac{V^2k_z^2}{\omega}\right]\frac{V^2k_x^2}{\omega}\Omega_T^2-\frac{4\varepsilon^2k_x^2V^2}{\omega}\Omega_T^2\left(\upsilon_0k_xk_z+\Omega_x\right)^2=0. \tag{18}$$

The above relation (18) reveals the combined authority of rotation, FLR corrections, radiative heat-loss function, thermal conductivity and porosity on the thermal instability of homogeneous plasma flowing via porous medium. We now decrease the relation (18) for longitudinal modes of propagation.

4. Discussion of the Dispersion Relation

4.1 Longitudinal Mode of Propagation (k||B)

In this case the perturbations are in use to be parallel to the track of the magnetic field (*i.e.* $k_x=0,\ k_z=k$). The dispersion relation (18) reduces to

$$\left(\omega^2+\Omega_T^2\right)\left\{\omega\left[\omega+\frac{V^2k^2}{\omega}\right]^2+4\varepsilon^2\Omega_x^2\left[\omega+\frac{V^2k^2}{\omega}\right]+\omega\left(2\varepsilon\upsilon_0k^2-2\varepsilon\Omega_z\right)^2\right\}-\Omega_T^2\left[\omega+\frac{V^2k^2}{\omega}\right]$$

$$\times4\varepsilon^2\Omega_x^2=0. \tag{19}$$

We see that the dispersion relation is amended because of the attendance of FLR corrections, rotation, radiative heat-loss function, porosity and thermal conductivity. This dispersion relation (19) is additional decreased for rotation axis parallel and perpendicular to the track of the magnetic field.

4.1.1 Axis of Rotation down the Magnetic Field (Ω||B)

For axis of rotation down the magnetic field, $\Omega_x=0$ and $\Omega_z=\Omega$ equation (19) diminishes to

$$\omega\left(\omega^2+\frac{\Omega_I^2+\omega\,\Omega_J^2}{\omega+B}\right)\left\{\left[\omega+\frac{V^2k^2}{\omega}\right]^2+\left(2\varepsilon\upsilon_0k^2-2\varepsilon\Omega\right)^2\right\}=0. \tag{20}$$

This dispersion relation shows the joint authority of rotation, FLR corrections, thermal conductivity, radiative heat-loss function, porosity on the thermal instability of the plasma. Equation (20) has three sovereign features. The first feature of equation (20) provides $\omega=0$, which is a subsidiary steady form. The second feature of equation (20) provides the pursuing dispersion relation on replacing the values of $\Omega_I^2, \Omega_J^2, \alpha$ and β.

$$\omega^3+\left[(\gamma-1)\left(\frac{T\rho L_T}{p}+\frac{\lambda k^2T}{p}\right)\right]\omega^2+\left(c^2k^2\right)\omega+\left[k^2(\gamma-1)\left(TL_T-\rho L_\rho+\frac{\lambda k^2T}{\rho}\right)\right]=0. \tag{21}$$

The circumstance of instability achieved from constant term of equation (21) is stated as

$$\left\{k^2(\gamma-1)\left(TL_T-\rho L_\rho+\frac{\lambda k^2T}{\rho}\right)\right\}<0, \tag{22}$$

The above circumstance of radiative instability is sovereign of rotation, FLR corrections and porosity. But depends on the radiative heat-loss functions and thermal conductivity.

The third factor of equation (20) on overview furnishes the following dispersion relation so equation (20) becomes

$$\omega^4+\left(2V^2k^2+4\varepsilon^2\Omega^2+4\varepsilon^2\upsilon_0^2k^4-8\varepsilon^2\Omega\upsilon_0k^2\right)\omega^2+V^4k^4=0. \tag{23}$$

The over equation denotes Alfven mode acclimatized by the attendance of rotation, porosity and FLR corrections. The roots of equation (23) are

$$\omega_{1,2}^2=-\left(V^2k^2+2\varepsilon^2\upsilon_0^2k^4+2\varepsilon^2\Omega^2-4\varepsilon^2\Omega\upsilon_0k^2\right)$$

$$\pm\left[\left(V^2k^2 2\varepsilon^2 \upsilon_0^2 k^4 + 2\varepsilon^2\Omega^2 - 4\varepsilon^2\Omega\upsilon_0 k^2\right)^2 - V^4k^4\right]^{1/2}. \qquad (24)$$

Hence rotation, porosity and FLR corrections alter the Alfven mode by modifying the growth rate of the system.

4.1.2 Axis of Rotation Perpendicular to the Magnetic Field ($\Omega \perp \mathbf{B}$)

For axis of rotation perpendicular to the magnetic field, we replacement $\Omega_x = \Omega$ and $\Omega_z = 0$ in the dispersion relation (19) which diminishes to give

$$\omega\left\{4\varepsilon^2\Omega^2\left[\omega^2 + \omega\frac{V^2k^2}{\omega}\right] + \left(\omega^2 + \frac{\Omega_I^2 + \omega\,\Omega_J^2}{\omega+\beta}\right)\right.$$
$$\left.\times\left[4\varepsilon^2\upsilon_0^2k^4 + \left(\omega + \frac{V^2k^2}{\omega}\right)^2\right]\right\} = 0. \qquad (25)$$

The dispersion relation reveals the combined influence of rotation, porosity, FLR corrections, radiative heat-loss function and thermal conductivity on the thermal instability of the plasma medium. This dispersion relation is the creation of two sovereign aspects. The first aspect $\omega = 0$, is a minor steady mode. The second aspect of equation (25) supplies, on substituting the values of Ω_I^2, Ω_J^2, α and β the following seven degree polynomial equation:

$$\omega^7 + \left[(\gamma-1)\left(\frac{T\rho L_T}{p} + \frac{\lambda k^2 T}{p}\right)\right]\omega^6 + \left[4\varepsilon^2\Omega^2 + 4\varepsilon^2\upsilon_0^2k^4 + 2V^2k^2 + c^2k^2\right]\omega^5 + \left[(\gamma-1)\left(\frac{T\rho L_T}{p}\right.\right.$$

$$\left.\left.+\frac{\lambda k^2 T}{p}\right)\left(4\varepsilon^2\Omega^2 + 4\varepsilon^2\upsilon_0^2k^4 + 2V^2k^2\right) + k^2(\gamma-1)\left(TL_T - \rho L_\rho + \frac{\lambda k^2 T}{\rho}\right)\right]\omega^4 + \left[\left(c^2k^2\right) + 4\varepsilon^2\right.$$

$$\left.\times\upsilon_0^2k^4\left(c^2k^2\right) + 2V^2k^2\left(2\varepsilon^2\Omega^2 + c^2k^2\right) + V^4k^4\right]\omega^3 + \left[(\gamma-1)\left(\frac{T\rho L_T}{p} + \frac{\lambda k^2 T}{p}\right)V^2k^2\left(4\varepsilon^2\Omega^2\right.\right.$$

$$+V^2k^2\Big)+\left(4\varepsilon^2\upsilon_0^2k^4+2V^2k^2\right)\left[k^2(\gamma-1)\left(TL_T-\rho L_\rho+\frac{\lambda k^2T}{\rho}\right)\right]\Big]\omega^2+\left[\left(c^2k^2\right)\left(V^4k^4\right)\right]\omega$$

$$+\left(V^4k^4\right)\left[k^2(\gamma-1)\left(TL_T-\rho L_\rho+\frac{\lambda k^2T}{\rho}\right)\right]=0. \tag{26}$$

The over dispersion relation symbolizes the outcome of porosity, radiative heat-loss function, thermal conductivity, rotation, and FLR corrections on the thermal instability of magnetized homogeneous plasma for longitudinal mode of propagation with axis of rotation perpendicular to magnetic field. The circumstance of instability accomplished from constant term of equation (26) is represented as

$$\left\{k^2(\gamma-1)\left(TL_T-\rho L_\rho+\frac{\lambda k^2T}{\rho}\right)\right\}<0. \tag{27}$$

The over circumstance of instability is alike to the condition (22) and discussed there. We terminate that for both the cases of rotation parallel and perpendicular to the direction of magnetic field, the circumstance of instability expanded is identical.

Equation (26) can be represented as

$$\omega^7+c_s\left[\left(k_T+k_\lambda k^2\right)\right]\omega^6+c_s^2\left[\frac{4\varepsilon^2\Omega^2}{c_s^2}+\frac{4\varepsilon^2\upsilon_0^2k^4}{c_s^2}+\frac{2V^2k^2}{c_s^2}+k^2\right]\omega^5+c_s^3\Big[\left(k_T+k_\lambda k^2\right)$$

$$\times\left(\frac{4\varepsilon^2\Omega^2}{c_s^2}+\frac{4\varepsilon^2\upsilon_0^2k^4}{c_s^2}+\frac{2V^2k^2}{c_s^2}\right)+\frac{k^2c_s^3}{\gamma}\left(k_T-k_\rho+k_\lambda k^2\right)\Big]\omega^4+c_s^4\Big[k^2+\frac{4\varepsilon^2\upsilon_0^2k^4\left(k^2\right)}{c_s^4}$$

$$+\frac{2V^2k^2}{c_s^2}\left(\frac{2\varepsilon^2\Omega^2}{c_s^2}+k^2\right)+\frac{V^4k^4}{c_s^4}\Big]\omega^3+c_s^5\Big[\left(k_T+k_\lambda k^2\right)\frac{V^2k^2}{c_s^2}\left(\frac{4\varepsilon^2\Omega^2}{c_s^2}+\frac{V^2k^2}{c_s^2}\right)$$

$$+\left(\frac{4\varepsilon^2\upsilon_0^2k^4}{c_s^2}+\frac{2V^2k^2}{c_s^2}\right)\left\{\frac{k^2c_s^5}{\gamma}\left(k_T-k_\rho+k_\lambda k^2\right)\right\}\Bigg]\omega^2+c_s^6\left[k^2\left(\frac{V^4k^4}{c_s^4}\right)\right]\omega$$

$$+\left(\frac{V^4k^4}{c_s^4}\right)\left[\frac{k^2c_s^7}{\gamma}\left(k_T-k_\rho+k_\lambda k^2\right)\right]=0. \tag{27}$$

Where we have used $k_\lambda=\dfrac{Rc_s\rho}{(\gamma-1)\lambda},\ k_T=\dfrac{(\gamma-1)L_T}{Rc_s},\ k_\rho=\dfrac{(\gamma-1)\rho L_\rho}{Rc_sT}.$ (28)

To study the effects of radiative heat loss functions, thermal conductivity, rotation and FLR corrections, we solve equation (27) arithmetically. Therefore equation (27) can be shown in non-dimensional form with the assist of below dimension-less quantities as given by Field (1965):

$$\omega^*=\omega/k_\rho c_s,\ k^*=k/k_\rho,k_\lambda^*=k_\rho/k_\lambda,k_T^*=k_T/k_\lambda,\upsilon_0^*=\upsilon_0k_\rho/c_s,\upsilon_c^*=\upsilon_ck_\rho/c_s,V^{*2}=V^2/c_s^2,$$
$$\varOmega^*=\varOmega k_\rho/c_s. \tag{29}$$

In astrophysical situations, instability of the association is one of the most important causes of arrangement of creature. So we learn the belongings of medium porosity ε, rotation $\varOmega^*$, and FLR corrections υ_0^* on the growth rate of unstable mode.

We represent the dispersion relation (26) in a non-dimensional form using parameters given by Field (1965) and the value of γ in arithmetical calculations is taken as 5/3.

$$\omega^{*7}+\left[\left(k_T^*+k_\lambda^*k^{*2}\right)\right]\omega^{*6}+\left[4\varepsilon^2\varOmega^{*2}+4\varepsilon^2\upsilon_0^{*2}k^{*4}+2V^{*2}k^{*2}\right]\omega^{*5}+\left(k_T^*+k_\lambda^*k^{*2}\right)\left(4\varepsilon^2\varOmega^{*2}+4\varepsilon^2\upsilon_0^{*2}k^{*4}\right.$$

$$\left.+2V^{*2}k^{*2}\right)k^{*2}\left\{\frac{1}{\gamma}\left(k_T^*+k_\lambda^*k^{*2}\right)-1\right\}\Bigg]\omega^{*4}+\left[4\varepsilon^2\upsilon_0^{*2}k^{*4}\left(k^{*2}\right)+2V^{*2}k^{*2}\left(2\varepsilon^2\varOmega^{*2}+k^{*2}\right)+V^{*4}k^{*4}-\left(k_T^*\right.\right.$$

$$\left.\left.+k_\lambda^*k^{*2}\right)\right]\omega^{*3}+\left[\left(k_T^*+k_\lambda^*k^{*2}\right)V^{*2}k^{*2}\left(4\varepsilon^2\varOmega^{*2}+V^{*2}k^{*2}\right)+\left(k_T^*+k_\lambda^*k^{*2}\right)V^{*2}k^{*2}\left(4\varepsilon^2\varOmega^{*2}+V^{*2}k^{*2}\right)\right.$$

$$\left.+\left(4\varepsilon^2\upsilon_0^{*2}k^{*4}+2V^{*2}k^{*2}\right)+k^{*2}\left\{\frac{1}{\gamma}\left(k_T^*+k_\lambda^*k^{*2}\right)-1\right\}\right]\omega^{*2}+\left[\left(k^{*2}\right)\left(V^{*4}k^{*4}\right)\right]\omega^*+\left(V^{*4}k^{*4}\right)$$

$$\times\left[k^{*2}\left\{\frac{1}{\gamma}\left(k_T^*+k_\lambda^* k^{*2}\right)-1\right\}\right]=0. \quad (30)$$

Mathematical computations were carried out to conclude the roots of ω^* as a function of wave number k^* for more than a few values of different parameters occupied fascinating $\gamma = 5/3$. Out of seven modes, only one mode is unbalanced for which the calculations are obtainable in figures 1-5, where the growth rate ω^* has been planned alongside the wave number k^* to demonstrate the confidence of the growth rate on the dissimilar physical limitations such as porosity, rotation and FLR corrections.

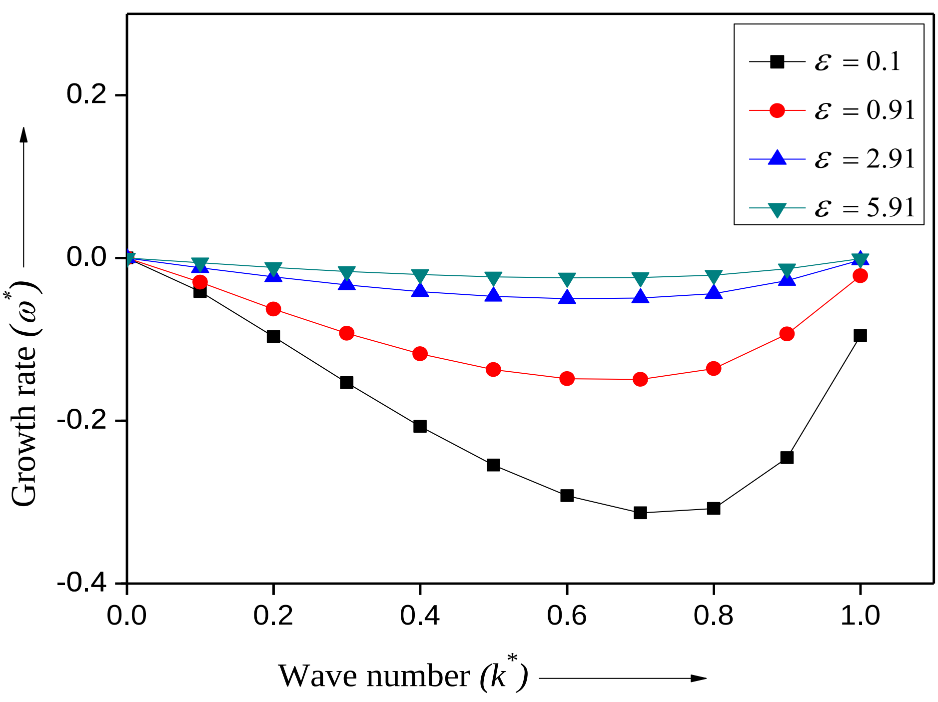

Fig. 1. Growth rate (ω^*) vs wave number k^* for four values of parameter ε keeping the other parameters fixed $k_T^* = 1.0, k_\lambda^* = 0, V^* = 1.0$, and $v_0^* = 1, \Omega^* = 1.0$.

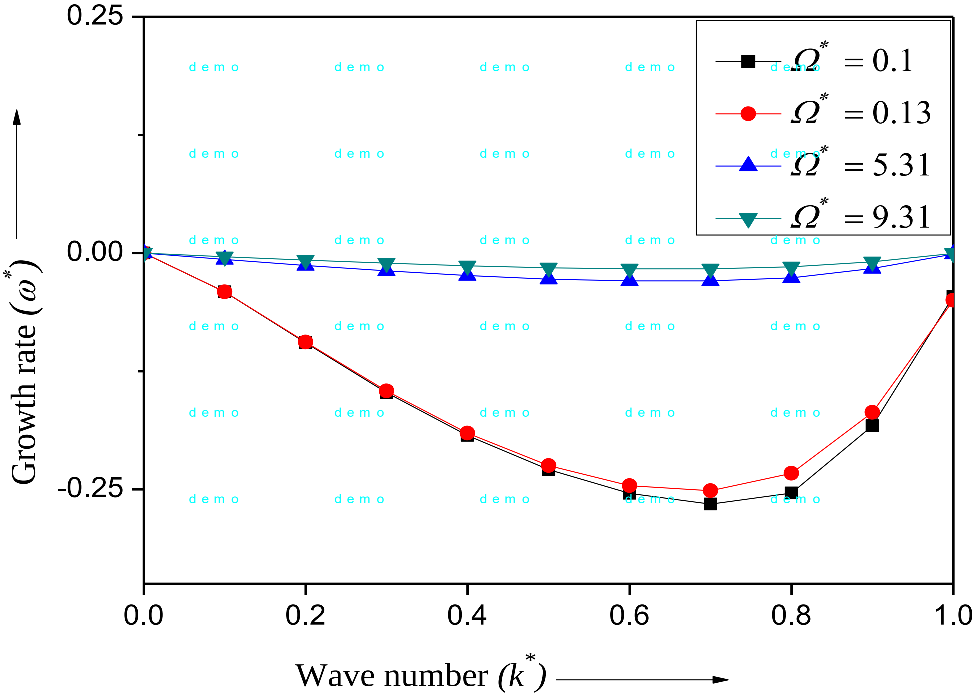

Fig. 2. Growth rate (ω^*) vs wave number (k^*) for four values of parameter Ω^* keeping the other parameters fixed $k_T^* = 1.0, k_\lambda^* = 0, V^* = 1, v_0^* = 1,$ and $\varepsilon = 1.0$.

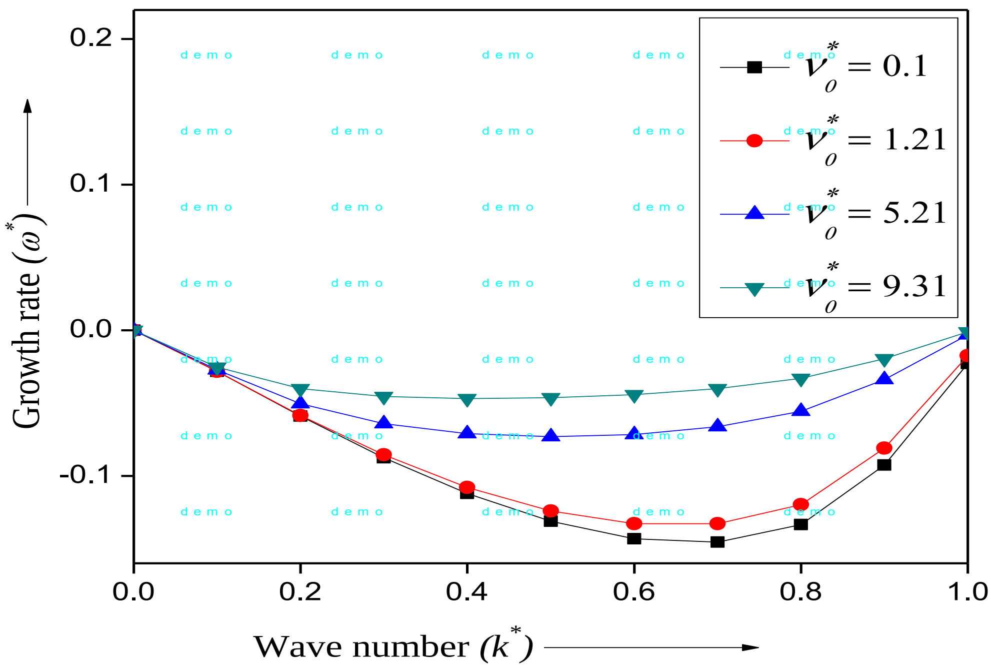

Fig. 3. Growth rate (ω^*)vs wave number (k^*) for four values of parameter v_0^* keeping the other parameters fixed $k_T^* = 1.0, k_\lambda^* = 0, V^* = 1, \Omega^* = 1,$ and $\varepsilon = 1.0$.

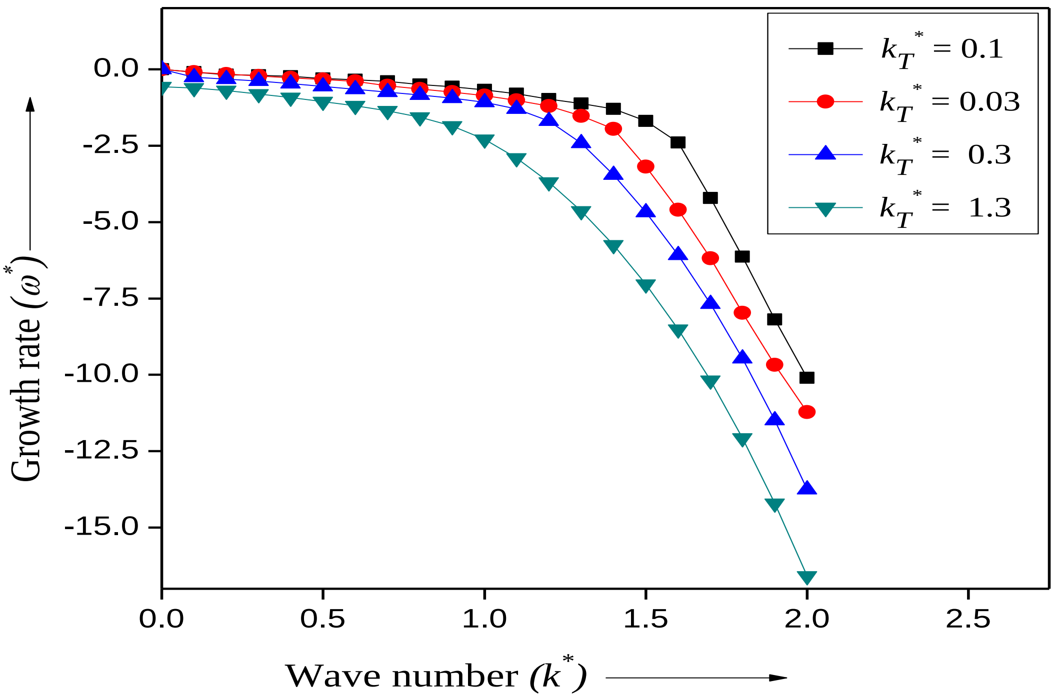

Fig. 4. Growth rate (ω^*)vs wave number (k^*) for four values of parameter k_T^* keeping the other parameters fixed $k_\lambda^* = 1.0, v_0^* = 1,$ $V^* = 1,$ $\Omega^* = 1,$ and $\varepsilon = 1.0.$

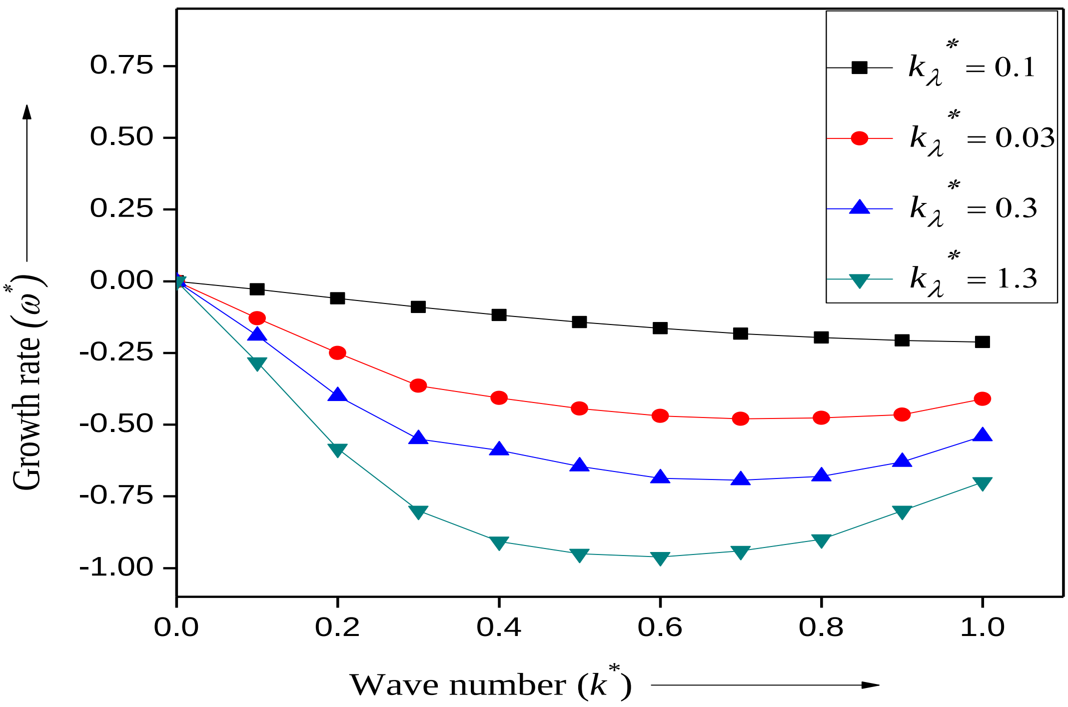

Fig. 5. Growth rate (ω^*)vs wave number (k^*) for four values of parameter k_λ^* keeping the other parameters fixed $k_T^* = 1.0, v_0^* = 0,$ $V^* = 1, \Omega^* = 1,$ and $\varepsilon = 1.0.$

It is obvious from fig. 1 that the peak value of the growth rate diminishes with increase in the value of medium porosity ε. Thus the effect of medium porosity ε is stabilizing on the growth rate of the system. From fig. 2, we see that the growth rate reduces with increase in the value of rotation Ω^*. Thus we terminate that rotation Ω^* stabilize the growth rate of the system. One can monitor from fig. 3 that the growth rate reduces with increasing FLR corrections υ_0^*. Thus the consequence of FLR corrections υ_0^* is stabilizing on the growth rate of the system. From fig. 4 it is clear that growth rate decreases on increasing the value of temperature dependent radiative heat-loss function k_T^*. So temperature dependent radiative heat-loss function k_T^*, shows stabilizing effect on the growth rate of the system. One can observe from fig. 5 that as the value of thermal conductivity k_λ^* increases the growth rate of the system decreases. So it is clear that thermal conductivity k_λ^* stabilize the growth rate of the system.

5. Conclusions

In the given study we have commended out the outcome of rotation, porosity and FLR corrections on the thermal instability of plasma adding up the impacts of radiative heat-loss function and thermal conductivity. The general dispersion relation is accomplished, which is modified due to the presence of measured substantial parameters. This dispersion relation is reduced for longitudinal wave propagation to the direction of magnetic field, which is further reduced for rotation axis parallel and perpendicular to the direction of magnetic field.

For longitudinal wave propagation to the direction of magnetic field with rotation axis along the magnetic field, we attained three dissimilar modes of propagation. The first mode is a subsidiary constant mode. The second mode is a non-thermal Alfven mode amended by the attendance of porosity, rotation and FLR corrections; it is sovereign of radiative heat-loss function and thermal conductivity. The third mode is customized by radiative heat-loss function and thermal conductivity; it is sovereign of rotation, FLR corrections and porosity. The thermal instability relies on radiative heat-loss function and thermal conductivity, we determine that the rotation, and FLR corrections have no impact on thermal criterion in this mode. In the case of rotation axis perpendicular to the magnetic field we once more attained the mode of propagation which provides the comparable consequence that is attained in the case of rotation axis along the magnetic field.

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