Influence of quantum radiative pressure on Jeans instability with electrical resistivity and Hall current

Devilal Sutar and Ram Kumar Pensia

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D. L. Sutar[1*] and R. K. Pensia[2]

[1*]Mewar University, Chittorgarh, Rajasthan, 312901 India
[2]S. J. Govt. Girls P. G. College, Neemuch, Madhya Pradesh, 458441 India

Devilalsutar833@gmail.com

Abstract

The influence of quantum radiative pressure and electrical resistivity incorporating the Hall current is studied on the Jeans instability of magnetized plasma. The basic equation of the problem is constructed and linearized by using the QMHD model. The general dispersion relation is derived using a normal mode technique and discussed in the parallel and perpendicular propagation. In the case of longitudinal propagation, the Jeans instability is modified due to quantum radiative pressure but is unaffected by electrical resistivity and Hall current. While in transverse propagation the electrical resistivity is modifying the growth rate of instability. In the graphical presentation, we found that the electrical resistivity has destabilizing influence but the presence of a quantum parameter is reduced the destabilizing effect of electrical resistivity in the system. The result is relevant to understanding many astrophysical problems.

Keyword - Quantum correction, Hall current, Radiative heat-loss function, electrical resistivity, and magnetic field.

1 Introduction

The plasma physics is one of the rapidly growing fields of science. It is an interdisciplinary science as it has wide potential applications in space and astrophysical conditions. In astroplasma physics, plasma has application in understanding the formation of molecular clouds, dust clusters and structures, star formation, nebulae, cometary tails, and magnetospheres etc. In astrophysical fluids, the collapse of an object is attributed to a self-gravitational force that is responsible for producing instability. And in order to understand the origin of star formation, the problem of self-gravitating interstellar plasma gas cloud is of considerable astrophysical significance. Jeans [1] gives a simple example of gravitational instability in an infinite homogeneous medium in connection with the fragmentation of interstellar matter in the formation of stars. Chandrasekhar [2] gives a great contribution to the self-gravitational instability on the magnetic field and rotation. The thermal instability in cooling and expanding medium including self-gravity and conduction in the neutral fluid dynamics has been investigated by Gomez-Pelaez and Moreno-Insertis [3]. Radwan [4] has studied the gravitational instability of radiating, rotating gas cloud streams with non-uniform velocity. Tsintsadze et al. [5] have discussed the importance of thermal radiation in the Jeans instability of magnetized dusty plasma. The Jeans instability of rotating anisotropic heat-conducting plasma has been analyzed by Prajapati et al. [6]. Pensia et al. [7] have studied the Jeans instability of quantum plasma under the influence of Hall effect. The gravitational instability of anisotropic plasma with Hall current is investigated by Ariel [8]. Bhatia [9] have studied the combined effects of Hall currents, finite conductivity, uniform rotation, and finite Larmor radius on gravitational instability. Shaikh et al. [10] have discussed the Jeans instability of thermally conducting plasma in a variable magnetic field with Hall current, finite conductivity, and viscosity. The self-gravitational instability of rotating viscous Hall plasma with arbitrary radiative heat-loss functions and electron inertia have examined by Prajapati et al. [11]. The quantum effect plays an important role in the structure formation through the gravitational collapsing process of many astrophysical objects, such as a white dwarf star, supernova, neutron stars, and magnetars. A quantum multi-stream model for one and two stream plasma instabilities is presented by Hass [12]. The Pines [13] introduced quantum plasma; he suggested that at very low temperatures the de Broglie wavelength of electrons and ions is of the order of the dimension of the system, such as Debye length and Larmor radius. In this type of dense plasma system plasma behaves like Fermi gas and we would treat it as quantum plasma. Recently many researchers used this QMHD model in their studies. Wu et al. [14] have investigated the effect of Hall term on Jeans instability in quantum magneto plasma with resistivity using the QMHD model. Also, Ren et al. [15] used the QMHD model to investigate the problem of Jean's instability of quantum magneto plasma considering resistivity effects. Masood *et al.* [16] investigated the self-gravitational instability of a multi-component quantum plasma using Bohm potential and statistical terms on electrons and ions. Recently Jain et al. [17] have discussed the effect of finite Larmor radius corrections on the thermal instability of thermal conducting viscous plasma with Hall current and electron inertia. The impact of Hall current and electrical resistivity on the stability of gravitating anisotropic quantum plasma is analyzed by Bhakta et al. [18].

Thus, we find that a large number of studies are done for the quantum magnetohydrodynamic model (QMHD) with different parameters under various assumptions. But no one considers the quantum magnetohydrodynamic model with radiation, electrical resistivity, and Hall current effect.

2 Linearized perturbation equation and Dispersion relation

We consider an infinite extended homogeneous, high density gravitating plasma containing electrons and singly charged ions including, Hall current, electrical resistivity, radiative heat-loss functions, and thermal conductivity. It is assumed that the above medium is permeated with a weak uniform magnetic field $\vec{B}(0,0,\mathrm{B})$ along the z-direction. The quantum effects introduced through the Bohm potential term in the momentum transfer equation describing quantum diffraction effects. The basic QMHD set of equations for quantum magnetoplasma is given by Hass [12]. In the present study, we have used QMHD set of equations.

The momentum transfer equation

$$\frac{\delta\vec{V}}{\delta t} = -\frac{\nabla\delta p}{\rho} + \nabla\delta\phi + \frac{1}{4\pi\rho}\left(\nabla\times\vec{b}\right)\times\vec{B} + \frac{\hbar^2}{4m_e m_i}\nabla\frac{(\nabla^2\delta\rho)}{\rho} \tag{1}$$

The equation of continuity

$$\frac{\partial \delta\rho}{\partial t} = -\rho \nabla . \vec{V} \tag{2}$$

Poisson's equation for a self-gravitational potential

$$\nabla^2 \delta\phi = -4\pi G \delta\rho \tag{3}$$

The induction equation for a magnetic field

$$\frac{\partial \vec{b}}{\partial t} = \nabla \times \left(\vec{V} \times \vec{B}\right) + \eta \nabla^2 \vec{b} - \frac{C}{4\pi N e}\left[\nabla \times \left\{\left(\nabla \times \vec{b}\right) \times \vec{B}\right\}\right] \tag{4}$$

Gauss's law of magnetism

$$\nabla . \vec{b} = 0 \tag{5}$$

The heat equation for a perfect gas including the radiative effect and thermal conduction

$$\frac{1}{(\gamma - 1)}\frac{\partial \delta\rho}{\partial t} - \frac{\gamma}{(\gamma - 1)}\frac{p}{\rho}\frac{\partial \delta\rho}{\partial t} + \rho\left(\mathcal{L}_\rho \delta\rho + \mathcal{L}_T \delta T\right) = \lambda \nabla^2 \delta T \tag{6}$$

The gas equation

$$\frac{\delta P}{P} = \frac{\delta T}{T} + \frac{\delta\rho}{\rho} \tag{7}$$

Where, $v(v_x, v_y, v_z), \rho, p, \phi, B(0,0,B), \eta, G, \lambda, R, \gamma, \hbar$, denote respectively, the gas velocity, density, fluid pressure, gravitational potential, magnetic field, electrical resistivity, gravitational constant, thermal conductivity, gas constant, the ratio of two specific heat, Plank's constant divided by $2\pi, m_e \ and \ m_i$ are the electron and ion mass. $\mathcal{L}_\rho$ is the partial derivatives of the density dependent $(\partial\mathcal{L}/\partial T)_T$ heat-loss function, $\mathcal{L}_T$ is the partial derivatives of the temperature dependent $(\partial\mathcal{L}/\partial T)_\rho$ heat-loss functions, δT is the temperature. With the help of equation (6) and (7), we obtained the expression for δp and get,

$$\delta p = \left(\frac{\alpha + \sigma C^2}{\sigma + \beta}\right)\delta\rho \tag{8}$$

Where $\sigma = i\omega$ is the growth rate of the perturbation, and $C = \left(\frac{\gamma p}{\rho}\right)^{1/2}$ is the adiabatic velocity of sound in the medium. The parameter $\alpha \ and \ \beta$ are

$$\alpha = (\gamma - 1)\left(\mathcal{L}_T T - \mathcal{L}_\rho \rho + \frac{\lambda k^2 T}{\rho}\right) \ and \ \beta = (\gamma - 1)\left(\frac{\mathcal{L}_T T\rho}{p} + \frac{\lambda k^2 T}{p}\right) \tag{9}$$

In order to study the stability of system we assume that the perturbed quantities vary as

$$exp\{i(k_x x + k_z z + \omega t)\} \tag{10}$$

Where ω is the frequency of harmonic disturbances, k_x and k_z are the wave numbers along x and z-direction to the magnetic field, such that $k_x^2 + k_z^2 = k^2$, $s = \delta\rho/\rho$ is the condensation of the medium. Solving equation (1-9) using equation (10) we obtain the following matrix relation,

$$X_{ij} Y_j = 0, \ \ i, j = 1,2,3,4, \tag{11}$$

Where X_{ij} is a 4×4 matrix whose elements are,

$$X_{11} = \left(\sigma + \frac{k^2 V^2 A_1}{A_2}\right), \quad X_{12} = -\frac{k^2 V^2 M k_z^2}{A_2} \quad X_{13} = 0, \quad X_{14} = \frac{i k_x}{k^2}\left(\Omega_T^2 + \frac{\hbar^2 k^4}{4 m_e m_i}\right)$$

$$X_{21} = \frac{k^2V^2Mk_z^2}{A_2}, \qquad X_{22} = \left(\sigma + \frac{k_z^2V^2A_1}{A_2}\right), \qquad X_{23} = 0, \qquad X_{24} = 0,$$

$$X_{31} = 0, \qquad X_{32} = 0, \quad X_{33} = \sigma, \qquad X_{34} = \frac{ik_z}{k^2}\left(\Omega_T^2 + \frac{\hbar^2k^4}{4m_em_i}\right),$$

$$X_{41} = \frac{ik_xk^2V^2A_1}{A_2}, \quad X_{42} = -\frac{ik_xk^2V^2Mk_z^2}{A_2}, \qquad X_{43} = 0, \qquad X_{44} = -\left(\sigma^2 + \Omega_T^2 + \frac{\hbar^2k^4}{4m_em_i}\right)$$

Where $V = \frac{B}{(4\pi\rho)^{1/2}}$ is the Alfven velocity, $C^2 = \gamma C'^2$ where C and $C'$are the adiabatic and isothermal velocities of sound. Also, we have assumed the following substitutions,

$$\Omega_J^2 = (k^2c^2 - 4\pi G\rho), \qquad \Omega_I^2 = (k^2\alpha - 4\pi G\rho\beta), \qquad \Omega_T^2 = \left(\frac{\sigma\Omega_J^2 + \Omega_I^2}{\sigma + \beta}\right), \Omega_m = \eta k^2,$$

$$A_2 = A_1^2 + A_3^2k^2k_z^2, \; A_1 = (\sigma + \Omega_m), \; A_3 = \frac{CB}{4\pi Ne}, \; A_4 = \left(\sigma + \frac{k_z^2V^2A_1}{A_2}\right)$$

Equation (11) has a non–trivial solution if the determinant of the matrix should vanish is to the following dispersion relation.

$$\Bigg[\left\{\sigma\left(\sigma + \frac{k^2V^2A_1}{A_2}\right)\left(\sigma + \frac{k_z^2V^2A_1}{A_2}\right)\left(\sigma^2 + \Omega_T^2 + \frac{\hbar^2k^4}{4m_em_i}\right)\right\} + \left\{\sigma\left(\sigma^2 + \Omega_T^2 + \frac{\hbar^2k^4}{4m_em_i}\right)\left(\frac{k_z^2k^2V^2A_3}{A_2}\right)^2\right\} - \left\{\frac{k_x^2}{k^2}\left(\Omega_T^2 + \frac{\hbar^2k^4}{4m_em_i}\right)\left(\frac{k^2V^2\sigma A_1A_4}{A_2} + \frac{k_z^4k^4V^4A_3^2\,\sigma}{A_2^2}\right)\right\}\Bigg] = 0 \tag{12}$$

The dispersion relation (12) shows the combined influence of Hall current, electrical resistivity, quantum correction, radiative heat-loss function, and magnetic field. If we neglect the effect of radiative heat-loss function, thermal conductivity and Hall current then dispersion relation (15) is identical to Ren *et al*. [15] excluding resistivity in that case. Thus the present result represents the modified dispersion relation for gravitational instability of quantum correction including the effect of Hall current, electrical resistivity, radiative heat-loss function, and magnetic field.

3 Discussion

For the discussion of dispersion relation (12) in an effective manner, we discuss it for the longitudinal and transverse mode of propagation.

3.1 Longitudinal propagation

In this case, we assume that all the perturbations are longitudinal to the direction of the magnetic field ($i.e., k_x = 0, \; k_z = k$) this dispersion relation reduces to a simple form,

$$\left[\sigma\left(\sigma^2 + \Omega_T^2 + \frac{\hbar^2k^4}{4m_em_i}\right)\left\{\left(\sigma + \frac{k^2V^2A_1}{A_2}\right)^2 + \left(\frac{k^4V^2A_3}{A_2}\right)^2\right\}\right] = 0 \tag{13}$$

The equation (13) shows the combined effect of thermal conductivity, magnetic field, self-gravitation, quantum plasma, electrical resistivity, heat-loss function and Hall current, the above equation have a tree independent factors, each represents the different parameters. The first factor of equation (13) is $\sigma = 0$ and represents the natural stability of the system. The second factor of equation (13) gives a cubic equation as

$$\sigma^3 + \sigma^2\beta + \sigma\left(\Omega_j^2 + \frac{\hbar^2 k^4}{4m_e m_i}\right) + \left\{\Omega_I^2 + \beta\left(\frac{\hbar^2 k^4}{4m_e m_i}\right)\right\} = 0 \tag{14}$$

The dispersion relation (14) is affected by the presence of thermal conductivity, quantum correction and radiative heat-loss function of the medium. This mode does not depend on Hall current, electrical resistivity, and magnetic fields. The above dispersion relation is the cubic equation in the power of σ, it will give us three roots, this odd-degree equation has always one real root of opposite sing to that of its constant term. The constant term of the above equation (14) is positive, it will give one real negative root and the system will be stable when the constant term is negative, it will give at least one real positive root, which gives the instability and here we considered plasma is unstable when

$$\left[k^2\left(\mathcal{L}_T T - \mathcal{L}_\rho \rho + \frac{\lambda k^2 T}{\rho}\right) + \left(\frac{\mathcal{L}_T T\rho}{p} + \frac{\lambda k^2 T}{p}\right)\left(\frac{\hbar^2 k^4}{4m_e m_i} - 4\pi G\rho\right) < 0\right] \tag{15}$$

The equation (15) represents a modified condition of self-gravitational instability due to the quantum correction but is independent that electrical resistivity, magnetic field, and Hall current in the longitudinal mode of propagation. If we reduced the influence heat-loss function and thermal conductivity in equation (14) the condition of gravitational instability is given by

$$\left[c^2 k^2 - 4\pi G\rho + \frac{\hbar^2 k^4}{4m_e m_i} < 0\right] \tag{16}$$

The equation (16) is a similar condition of gravitational instability is given by Ren et al. [15]. For a thermally non-conducting and non-radiating classical plasma medium, the dispersion relation (14) reduced to

$$\sigma^2 + \Omega_j^2 = 0 \tag{17}$$

From equation (17) it is clear that when $\Omega_j^2 < 0$, the product of the roots of equation (17) must be negative. This implies that at least one root of σ is positive, so the system is unstable. The condition of instability is given by equation (17)

$$c^2 k^2 - 4\pi G\rho < 0 \tag{18}$$

$$k < k_j = \left(\frac{4\pi G\rho}{c^2}\right)^{\frac{1}{2}} \tag{19}$$

Where the k_j is the Jeans wave number and the above equation (19) is obtained by Jeans self-gravitational instability criterion. The condition of instability is identical to Chandrasekhar [2]. We find that the condition of Jeans criteria is modify the presence of quantum correction, thermal conductivity and heat-loss function but is not affected by electrical resistivity and Hall current.

Now the third factor of the equation of (13) is equating to zero and then solved it we get the dispersion relation.

$$\sigma^6 + 3\Omega_m\sigma^5 + 2\sigma^4(k^4A_3^2 + k^2v^2) + \sigma^3\left(3\Omega_m^4 + 4k^4A_3^2\Omega_m + 6k^2v^2\Omega_m\right) + \sigma^2\left(\Omega_m^4 + 2k^4A_3^2\Omega_m^2 + k^8A_3^4 + 6k^2v^2\Omega_m^2 + 2k^6v^2A_3^2 + k^4v^4\right) + 2\sigma\left(k^2v^2\Omega_m^3 + k^6v^2A_3^2\Omega_m + k^4v^4\Omega_m\right) + k^4v^4\Omega_m^2 + k^8v^4A_3^4 = 0 \quad (20)$$

The dispersion relation (20) involves electrical resistivity, magnetic field and Hall current but is does not involves thermal conductivity, radiative heat-loss function. It is shown that in the above equation the growth rate of instability and Jeans criterion of instability is modified by electrical resistivity and Hall current.

3.2 Transverse propagation

For this case, we assume all the perturbation are propagating perpendicular to the direction of the magnetic field, we take $k_x = k,\ \ k_z = 0$. The dispersion relation (12) can be written as

$$\sigma^3\left[\sigma^4 + \sigma^3(\beta + \Omega_m) + \sigma^2\left(\beta\Omega_m + \Omega_j^2 + \frac{\hbar^2k^4}{4m_em_i} + k^2v^2\right) + \sigma\left(\Omega_I^2 + \Omega_m\Omega_j^2 + \frac{\beta\hbar^2k^4}{4m_em_i} + \frac{\Omega_m\hbar^2k^4}{4m_em_i} + \beta k^2v^2\right) + \Omega_I^2\Omega_m + \beta\Omega_m\frac{\hbar^2k^4}{4m_em_i}\right] = 0 \quad (21)$$

The first factor of propagating is spurious stable mode independent of all the effects and represents natural stability. The second factor of dispersion relation (21) gives

$$\sigma^4 + \sigma^3(\beta + \Omega_m) + \sigma^2\left(\beta\Omega_m + \Omega_j^2 + \frac{\hbar^2k^4}{4m_em_i} + k^2v^2\right) + \sigma\left(\Omega_I^2 + \Omega_m\Omega_j^2 + \frac{\beta\hbar^2k^4}{4m_em_i} + \frac{\Omega_m\hbar^2k^4}{4m_em_i} + \beta k^2v^2\right) + \Omega_I^2\Omega_m + \beta\Omega_m\frac{\hbar^2k^4}{4m_em_i} = 0 \quad (22)$$

The above dispersion relation (22) shows the combined influence of the magnetic field, radiative heat-loss function, electrical resistivity, quantum correction but is not affected by Hall current in the transverse mode of propagation. The condition of instability is obtained from the constant term of the dispersion relation (22), and it is given by

$$\left[k^2\Omega_m\left(\mathcal{L}_TT - \mathcal{L}_\rho\rho + \frac{\lambda k^2T}{\rho}\right) + \Omega_m\left(\frac{\mathcal{L}_TT\rho}{p} + \frac{\lambda k^2T}{p}\right)\left(\frac{\hbar^2k^4}{4m_em_i} - 4\pi G\rho\right) < 0\right] \quad (23)$$

We write the dispersion relation (23) in non-dimensional form, for showing the effects of the different parameter on the growth rate of instability, as

$$\sigma^{*4} + \sigma^{*3}(\beta^* + \eta^*k^{*2}) + \sigma^{*2}(\beta^*\eta^*k^{*2} + k^{*2} - 1 + Q^*k^{*2} + k^{*2}V^{*2}) + \sigma^*(k^{*2}\alpha^* - \beta^* + \eta^*k^{*4} - 1 + \beta^*Q^*k^{*2} + \eta^*k^{*4}Q^* + \beta^*k^{*2}V^{*2}) + \eta^*k^{*4}\alpha^* - \beta^*\eta^*k^{*2} + \beta^*\eta^*k^{*4}Q^* = 0 \quad (24)$$

Where the various non-dimensional parameters are defined as

$$\sigma^* = \frac{\sigma}{\sqrt{4\pi G\rho}},\ k^* = \frac{kC}{\sqrt{4\pi G\rho}},\ Q^* = \frac{\hbar^2k_j^2}{4m_em_i},\ V^* = \frac{V\sqrt{4\pi G\rho}}{C},\ \lambda^* = \frac{(\gamma-1)T\lambda\sqrt{4\pi G\rho}}{\rho C^2},\ \ \mathcal{L}_\rho^* = \frac{(\gamma-1)\rho\,\mathcal{L}_\rho}{C^2\sqrt{4\pi G\rho}},\ \ \mathcal{L}_T^* = \frac{(\gamma-1)\rho\,T\mathcal{L}_T}{\rho\sqrt{4\pi G\rho}},\ \alpha^* = \left(\frac{1}{\gamma}(\mathcal{L}_T^* + \lambda^*k^{*2}) - \mathcal{L}_\rho^*\right),\ \ \beta^* = (\mathcal{L}_T^* + \lambda^*k^{*2}),\ \ \ \eta^* = \frac{\eta\sqrt{4\pi G\rho}}{C^2},\ \Omega_I^{*2} = (k^{*2}\alpha^* - \beta^*),\ \Omega_j^{*2} = (k^{*2} - 1) \quad (25)$$

In Figure 1-4 we have depicted the non-dimensional growth rate versus non-dimensional wave number for various values of the magnetic field and electrical resistivity, and fixed values of temperature dependent heat-loss function, density dependent heat-loss function, thermal conductivity, and quantum correction.

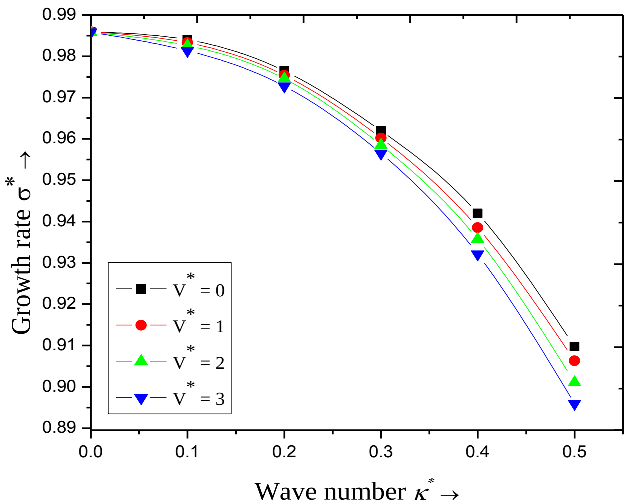

Figure 1: The growth rate $\boldsymbol{\sigma}^*$, in the transverse mode, is plotted against wave number $\boldsymbol{k}^*$ with variation in the magnetic field $\boldsymbol{V}^* = (\mathbf{0}, \mathbf{1}, \mathbf{2}, \mathbf{3})$, keeping the values of other parameters are fixed, as $\boldsymbol{\mathcal{L}}_{\boldsymbol{\rho}}^* = \boldsymbol{\mathcal{L}}_{\boldsymbol{T}}^* = \boldsymbol{\lambda}^* = \boldsymbol{Q}^* = \mathbf{0.5}\ \boldsymbol{and}\ \boldsymbol{\eta}^* = \mathbf{0}$

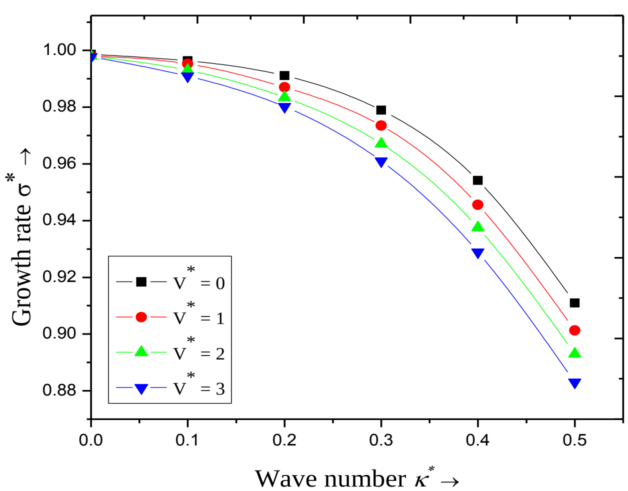

Figure 2: The growth rate $\boldsymbol{\sigma}^*$, in the transverse mode, is plotted against wave number $\boldsymbol{k}^*$ with variation in the magnetic field $\boldsymbol{V}^* = (\mathbf{0}, \mathbf{1}, \mathbf{2}, \mathbf{3})$, keeping the values of other parameters are fixed, as $\boldsymbol{\mathcal{L}}_{\boldsymbol{\rho}}^* = \boldsymbol{\mathcal{L}}_{\boldsymbol{T}}^* = \boldsymbol{\lambda}^* = \boldsymbol{Q}^* = \mathbf{0.5}\ \boldsymbol{and}\ \boldsymbol{\eta}^* = \mathbf{1.5}$

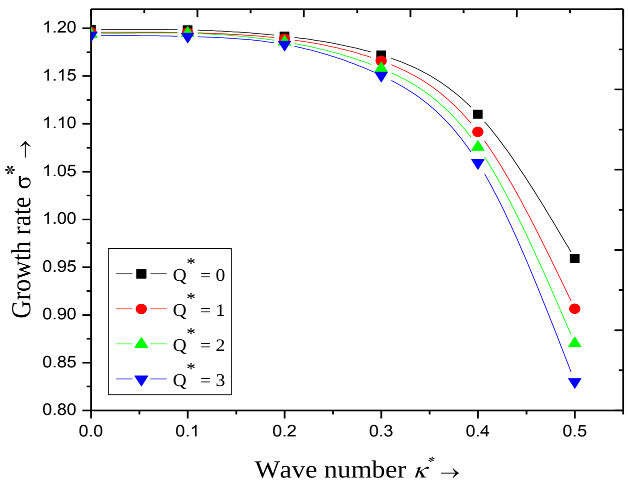

Figure 3: The growth rate $\boldsymbol{\sigma}^*$, in the transverse mode, is plotted against wave number $\boldsymbol{k}^*$ with variation in the quantum correction $\boldsymbol{Q}^* = (\mathbf{0}, \mathbf{1}, \mathbf{2}, \mathbf{3})$, keeping the values of other parameters are fixed, as $\boldsymbol{\mathcal{L}}_{\boldsymbol{\rho}}^* = \boldsymbol{\mathcal{L}}_{\boldsymbol{T}}^* = \lambda^* = \boldsymbol{V}^* = \mathbf{0.5}$ ***and*** $\boldsymbol{\eta}^* = \mathbf{0}$

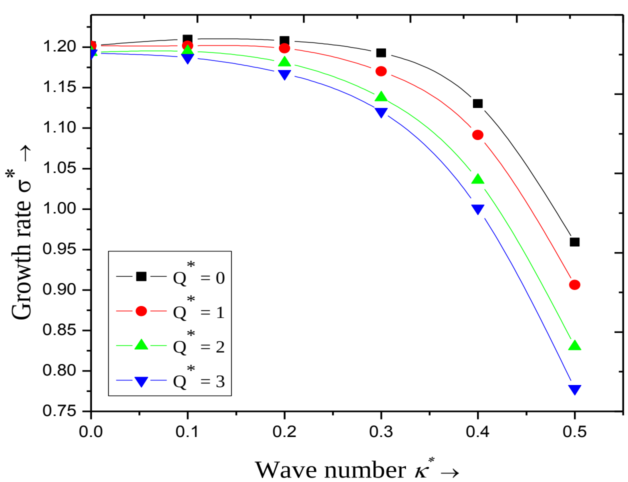

Figure 4: The growth rate $\boldsymbol{\sigma}^*$, in the transverse mode, is plotted against wave number $\boldsymbol{k}^*$ with variation in the quantum correction $\boldsymbol{Q}^* = (\mathbf{0}, \mathbf{1}, \mathbf{2}, \mathbf{3})$, keeping the values of other parameters are fixed, as $\boldsymbol{\mathcal{L}}_{\boldsymbol{\rho}}^* = \boldsymbol{\mathcal{L}}_{\boldsymbol{T}}^* = \lambda^* = \boldsymbol{V}^* = \mathbf{0.5}$ ***and*** $\eta^* = \mathbf{1.5}$

From figure 1-4, the dimensionless growth rate is plotted against the dimensionless wave number for different values of the magnetic field and quantum correction. It is quite obvious from the figures that with an increase in a magnetic field and quantum correction there is a decrease in the growth rate of the system. Thus, the magnetic field and quantum correction have a stabilizing influence on the system but the presence of electrical resistivity the growth rate of the system is increasing and the system is destabilized.

4 Conclusion

In this paper we have investigate a theoretical study of Jeans instability of a quantum radiative pressure with resistivity and Hall current. We have derived a general dispersion relation using normal mode analysis and QMHD equation. In the case of longitudinal propagation the Alfven wave mode modified in the presence of electrical resistivity and Hall current. The dispersion relation for the transverse mode is unaffected by the presence of Hall current. The gravitational instability is obtained which is modified by electrical resistivity, magnetic field, quantum correction, thermal conductivity, and radiative heat-loss function. From the curves, we find that the magnetic field and quantum correction have stabilized the system when we reduced the impact of electrical resistivity, but the presence of the electrical resistivity system is destabilized. We conclude that electrical resistivity has a destabilizing effect on the growth rate of instability while the magnetic field and quantum parameter have to stabilize the system.

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