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Role of Fine Dust Particles on Jeans Instability Under the Effect of Finite Electron Inertia

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Abstract

The Jeans instability of homogeneous gaseous Plasma is discussed to investigate the effect of viscosity, rotation, thermal-conductivity, electrical-resistivity, electron inertia and role of presence of fine dust particles and magnetic field on the self-gravitational instability. The usual magneto-hydrodynamic (MHD) equations are used for the present configuration with thermal-conductivity and finite dust particles. A general dispersion relation is obtained from the linearized perturbation equations using the normal mode analysis method. It is found that the Jeans criterion of instability is modified due to the presence of various parameters considered in our problem. The stability and instability are discussed for various cases as our interest.

Key words: Thermal conductivity, Finite Electron Inertia, Suspended Particles,Rotation, Magnetic - Field, Electrical Resistivity.

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1. Introduction

The gravitational instability of a gaseous plasma is important for under-standing various astrophysical problems. The self-gravitational instability of molecular clouds is connected to the cloud collapse and the formation of stars. Jeans first considered the gravitational instability of an infinite homogeneous medium[1,2]. The analysis is very simple because with Jeans assumption of a homogeneous medium of infinite extent there are no equilibrium self-field forces between the mass and the gravitational field produced by the mass, Presumably, this is because any particular mass element is attracted both by all the mass above it and by all the mass below it.

A detailed contribution of the self-gravitational instability with different assumptionson the magnetic-field and rotational has been discussed by Chandrasekhar[3]. An this connection, many authors have investigated the gravitational instability of a homogeneous plasma considering the influences of various parameters[4-11].

Recently, Prajapati *et al.*[12] has studied the self-gravitational instability of a rotating anisotropic heat-conducting Plasma[13,14].

From the above studies, we find that fine dust particles and electron inertia are the important parameters to discuss the Jeans instability of infinite homogeneous magnetized gaseous plasma. Thus, in the present problem, we investigate the effects of fine dust particles and electron inertia on the self-gravitational instability of arotating,viscous plasma with thermal-conductivity and electrical-resistivity.

2. Linearized Perturbation Equations:

We consider an infinite homogeneous, viscous, Self-gravitating, rotating ionized plasma medium including finite electrical resistivity, fine dust particles (suspended particles) incorporating thermal conducting and finite electron inertia in the presence of magnetic field $\vec{B}(0,0,B)$.

Linearized Perturbation Equations of the Problem are,

$$\frac{\delta\vec{v}}{\delta t} = -\frac{\vec{\nabla}\delta P}{\rho} + \vec{\nabla}\delta\phi + \frac{KN}{\rho}(\vec{u}-\vec{v}) + \vartheta\nabla^2\vec{v} + \frac{1}{4\pi\rho}\left(\vec{\nabla}\times\vec{b}\right)\times\vec{B} + 2\left(\vec{v}\times\vec{\Omega}\right) \quad (1)$$

$$\frac{\partial\delta\rho}{\partial t} = -\rho\vec{\nabla}.\vec{v} \quad (2)$$

$$\delta P = C^2\delta P \quad (3)$$

$$\nabla^2\delta\phi = -4\pi G\delta\rho \quad (4)$$

$$\left(\tau\frac{\partial}{\partial t}+1\right)\vec{u} = \vec{v} \quad (5)$$

$$\lambda\nabla^2\delta T = \rho C_p\frac{\partial\delta t}{\partial t} - \frac{\partial\delta P}{\partial t} \quad (6)$$

$$\frac{\delta P}{P} = \frac{\delta T}{T} + \frac{\delta\rho}{\rho} \quad (7)$$

$$\frac{\partial\vec{b}}{\partial t} = \vec{\nabla}\times\left(\vec{u}\times\vec{B}\right) + \eta\nabla^2 b + \frac{C^2}{\omega_{pe}^2}\frac{\partial}{\partial t}\nabla^2\vec{b} \quad (8)$$

Where,

$\vec{v}(v_x, v_y, v_z)$, $\vec{u}(u_x, u_y, u_z)$, N, ρ, P, ϕ, $\vec{B}(0,0,B)$, $\vec{\Omega}(\Omega_x, 0, \Omega_z)$, $T, G, \vartheta, C_p, \lambda, R$, m, ρ_s, ω_{pe}, $K_s(6\pi\rho r)$ *and* $\vec{b}(b_x, b_y, b_z)$, denote respectively, the gas velocity, the particle velocity, the number density of the particle, density of the gas, pressure of the gas, Gravitational potential, magnetic field, rotation, temperature, Gravitational constant, kinematic viscosity, specific heat at constant pressure, thermal conductivity, gas constant, mass per unit volume of the particles its density, plasma frequency of electron, the constant is the stokes drag formula, perturbation in magnetic field and η is the electrical conductivity.

3. Dispersion relation :

We analyse these perturbations with normal oscillation technique, we find solution of equation (1)-(8). In a uniform system we can find a plane-wave solution with all variables varying as,

$$exp\{i(k_x, k_z, \omega t)\} \quad (9)$$

Where k_x, k_z are the wave numbers of perturbation along the x-axis and z-axis and ω is growth rate of the perturbations, so that $k_x^2 + k_z^2 = k^2$ and the frequency of harmonic disturbances, Using (2)-(9) in (1), we obtain the following algebraic equations for the components.

$$Q_1 v_x - 2\Omega_z v_y + \frac{ik_x}{k^2}\Omega_I^2 s = 0 \quad (10)$$

$$2\Omega_z v_x + Q_2 u_y - 2\Omega_z v_z = 0 \quad (11)$$

$$2\Omega_x u_y + M v_z + \frac{ik_z}{k^2}\Omega_I^2 s = 0 \quad (12)$$

The divergence of (1) with the aid of (2)-(9) gives

$$\frac{ik_x v^2 k^2}{a_1} v_x + 2iQ_4 v_y - Q_3 s = 0 \quad (13)$$

Where $s = \frac{\delta\rho}{\rho}$ is the condensation of the medium

$\gamma = \frac{C_p}{C_v} = \frac{C^2}{C'^2}$ ratioof the specific heat,

$V = \frac{B}{\sqrt{4\pi\rho}}$ is the Alfven velocity,

$\Omega_s = \frac{KN}{\rho}$ has the dimension of frequency,

$\tau = \frac{m}{K_s}$ is the relaxation time,

$\beta = \tau\Omega_s = \frac{\rho_s}{\rho}$ is the mass conservation,

$\sigma = i\omega$ is the growth rate ofperturbation,

$\Omega_\vartheta = \vartheta K^2, \quad a_1 = \sigma f + \Omega_m, \quad f = \left(1 + \frac{C^2K^2}{\omega_{pe}^2}\right),$

$\theta_k = \frac{\lambda}{\rho C_p}$ is the thermometric Conductivity,

$\Omega_m = \eta K^2$ electrical resistivity.

C and C' is the adiabatic and isothermal velocities of sound.

$M = \sigma + \Omega_\vartheta + \frac{\beta\sigma}{\sigma\tau + 1}, \ \Omega_j^2 = (C^2K^2 - 4\pi G\rho),$

$\Omega_{j'}^2 = (C'^2K^2 - 4\pi G\rho), \ \Omega_I^2 = \frac{\sigma\Omega_j^2 + \gamma_k\Omega_{j'}^2}{\sigma + \gamma_k},$

$Q_1 = \left(M + \frac{V^2K^2}{A_1}\right), \quad Q_2 = \left(M + \frac{V^2K_z^2}{A_1}\right),$

$Q_3 = (\sigma M + \Omega_I^2), \quad Q_4 = (k_x\Omega_z - \Omega_x k_z),$

The nontrivial solution of the determinant of the matrix obtained from (11)-(13)with (v_x, v_y, v_z, s) having various coefficients, that should vanish is to give the following dispersion relation.

$$M\left[\sigma M\{Q_1Q_2+4\Omega^2\}+\frac{4\Omega_x^2V^2K^2\sigma}{a_1}+\Omega_I^2\left\{Q_2^2+4\Omega^2-\frac{4Q_4^2}{K^2}\right\}\right]=0 \quad (15)$$

The dispersion relation (15) shows the combined influence of fine dust-particles, electrical-conductivity, thermal-conductivity, finite electron inertia, magnetic field, viscosity and rotation of the self-gravitational instability of a homogeneous plasma. If we ignore the effect of finite electron-inertiaand electrical-resistivity then[15] reduces to Chhajlani andVyas[4]. Thepresent results are also similar to those of Chhajlaniand Sanghvi[3]. Inthe absence of rotation, electrical-resistivity and finite electron-inertia neglecting the contribution of finite Larmor radius (FLR) connection and Hallparameter in that case.In the absence of finite fine dust particles (15) give similar result as are obtained by Prajapati *et al*.[5]. excluding the effects of arbitrary radiative heat-loss functions, permeability,electrical-resistivity and Hall-effect in that case.

Thus with these correlations we find that the dispersion relation (15) is modified due to the combined effects of electrical-resistivity, finite dust particles, finite electron-inertia, rotation , resistivity, magnetic field, viscosity and thermal conductivity. This dispersion relation well be able to predict the complete information about the acoustic wave, Alfven wave and Jeans gravitational instability of the gaseous plasmas considered. The above dispersion relation is very lengthy and to analysis the effects of each parameter we now reduce the dispersion relation (15) for two modes of propagation.

4. Analysis of the dispersion relation.

4.1. Longitudinal mode of propagation $(\boldsymbol{K} \parallel \boldsymbol{B})$:

For this case we assume that all the perturbations and longitudinal to the direction of the magnetic field $(i.e. K_z = K,\ K_x = 0)$.

Thus the dispersion relation (15) reduces in the simple from to give

$$\sigma M\left\{\left(M+\frac{K^2V^2}{a_1}\right)^2+4\Omega^2\right\}+\frac{4\sigma V^2K^2}{a_1}\Omega_x^2+\Omega_I^2\left\{\left(M+\frac{K^2V^2}{a_1}\right)^2+4\Omega_z^2\right\}=0 \quad (16)$$

This dispersion relation is further reduced for rotational axes are parallel and perpendicular to the direction of the magnetic field for simplicity.

4.1.1. Axis of rotation parallelto the magnetic-field $(\boldsymbol{\Omega} \parallel \boldsymbol{B})$:

When the axis of rotation is along the magnetic field, *i.e.* $\Omega_x = 0$ and $\Omega_z = \Omega$. Then (16) reduces to as

$$(\sigma M+\Omega_I^2)\left[\left(\sigma+\Omega_\vartheta+\frac{\beta\sigma}{\sigma\tau+1}+\frac{K^2V^2}{a_1}\right)^2+4\Omega^2\right]=0 \quad (17)$$

This dispersion relation shows the combined influence of electrical-resistivity, fine dust particles, finite electron inertia, resistivity, viscosity, rotation,magnetic field and thermal conductivity on the self-gravitational instability of the hydro-magnetic fluid plasma.In the absence of fine dust particles, finite electron inertia, permeability, rotation and resistivity. This dispersion relation reduces to that Chhajlani and patidar[5]. The dispersionrelation (17) is the product of relation two independent factors.These factors show mode of propagations incorporating different parameters as discussed below.

The first factor of (17) is identical to that of chhajlani and vyas with porosity $\boldsymbol{\varepsilon = 1}$ by absence of electrical-resistivityin that case and has been discussed by them. This represents a stable damped mode modified due to the viscosity, finite dust particles and thermal conductivity. The dynamical stability of the system can be examined by applying the Hurwitz criterion on the mode of propagation represented by first factor of the dispersion relation (17). It can also be seen that, for the longitudinal propagation in the medium, Jeans condition remains unaltered even by the inclusion of the effect of fine dust particles and finite electron inertia. Owing to the inclusion of thermal conductivity the isothermal sound velocity is replaced by the adiabatic velocity of sound.

The secondfactor of (17) gives, on substituting the value of M , a_1 the following Six degree polynomial equation.

$$\begin{aligned}
&\tau^2 f^2\sigma^6 + 2\tau\sigma^5[f^2\{1+\tau(\beta+\Omega_\vartheta)\} + \tau f\Omega_m] \\
&+ \sigma^4\left[f^2\{1+\tau(\beta+\Omega_\vartheta)\}^2 + 2\tau f(\Omega_\vartheta f + \tau K^2V^2) + \tau^2 f^2 4\Omega^2 \right.\\
&\left. + 4\tau f\Omega_m\{1+\tau(\beta+\Omega_\vartheta) + \tau^2\Omega_m^2\}\right] \\
&+ \sigma^3\left[2\tau f K^2V^2 + \tau f^2 8\Omega^2 + 2f(f\Omega_\vartheta + \tau K^2V^2)\{1+\tau(\beta+\Omega_\vartheta)\}\right.\\
&\left. + 2f\Omega_m\{(\tau\Omega_\vartheta+1)^2 + \beta\tau(2+\beta\tau+2\tau\Omega_\vartheta) + \tau^2 4\Omega^2\}\right] \\
&+ \sigma^2\left[(f\Omega_\vartheta + \tau K^2V^2)^2 + 2fK^2V^2\{1+\tau(\beta+\Omega_\vartheta)\} + f^2 4\Omega^2 + 4f\Omega_m\Omega_\vartheta\{1+\tau(\beta+\Omega_\vartheta)\}\right.\\
&+ \tau f\Omega_m 16\Omega^2 \\
&\left. + \Omega_m^2\{(\beta+\Omega_\vartheta)\left(2\tau^2K^2V^2 + \tau^2\Omega_\vartheta + \tau^2\beta + 2\tau + 1 + \tau^2 4\Omega^2 + 2\tau\Omega_\vartheta + 2K^2V^2\right)\}\right] \\
&+ \sigma\left[2K^2V^2(f\Omega_\vartheta + \tau K^2V^2) + 2f\Omega_m\left(\Omega_\vartheta^2 + 4\Omega^2\right) + 2\Omega_m^2\{1+\tau(\beta+\Omega_\vartheta)\}(\Omega_\vartheta + K^2V^2)\right.\\
&\left. + 2\tau\Omega_m^2\left(\Omega_\vartheta K^2V^2 + \tau 4\Omega^2\right)\right] + \Omega_m^2\left(\Omega_\vartheta^2 + 2\Omega_\vartheta K^2V^2 + 4\Omega^2\right) + K^4V^4 \\
&= 0 \qquad (18)
\end{aligned}$$

The dispersion relation (18) is a non-gravitating Alfven mode modified by the presence of finite electrical-resistivity,fine dust particles,finite electron- inertia, viscosity, resistivity and rotation. We findthat inthis dispersion relation the terms due to the finite electron inertia have entered through the factor of .

4.1.2. Axis of rotation perpendicular to the magnetic-field $(\boldsymbol{\Omega \perp B})$.

In the case of a rotation axis perpendicular to the magnetic field, we put $\Omega_x = \Omega$ and $\Omega_z = 0$ in the dispersion relation (16) and this gives,

$$(Ma_1 + K^2V^2)\left[(Ma_1 + K^2V^2)(\sigma M + \Omega_I^2) + 4\sigma a_1 \Omega^2\right] = 0 \qquad (19)$$

This dispersion relation is the product of two independent factors. These factors show the mode of propagations incorporating different parameters as discussed below.

The first factor of (19) also represents a stable non-gravitating Alfven mode modified by fine dust particles, finite electron inertia and viscosity but this mode is not affected by rotation.

Thus we see that Alfven mode is not affected by rotation in longitudinal mode of propagation when axis of rotation is taken perpendicular to the direction of magnetic field while this non-gravitating Alfven mode is affected by rotations when axis of rotation is taken to parallel to the magnetic field. The second factor (19) gives on substituting the values of M , a_1 and Ω_I^2, the following seven degree polynomial equation.

$$\begin{aligned}
&\tau^2\sigma^7 f + \sigma^6\left[\tau f\{2 + \tau(2\Omega_\vartheta + 2\beta + \theta_k)\} + \tau^2\Omega_m^2\right] \\
&+ \sigma^5\left[f\{1 + 2\tau(2\Omega_\vartheta + \beta + \theta_k)\} + \tau^2\{f\Omega_j^2 + K^2V^2 + 4f\Omega^2 + f(\beta + \Omega_\vartheta)(\Omega_\vartheta + \beta + 2\theta_k)\}\right. \\
&\left. + 2\tau\Omega_m\{1 + \tau(\beta + \Omega_\vartheta)\} + \tau^2\Omega_m\theta_k\right] \\
&+ \sigma^4\left[f(2\Omega_\vartheta + \theta_k) + 2\tau\{f\Omega_j^2 + K^2V^2 + f4\Omega^2 + f(\beta + \Omega_\vartheta)(\Omega_\vartheta + \theta_k) + f\Omega_\vartheta\theta_k\}\right. \\
&+ \tau^2\{\theta_k(f\Omega_{j'}^2 + K^2V^2 + f4\Omega^2) + (\beta + \Omega_\vartheta)(f\Omega_j^2 + K^2V^2 + f\beta\theta_k + f\Omega_\vartheta\theta_k)\} \\
&\left. + \Omega_m\{1 + 2\tau(2\Omega_\vartheta + \beta + \theta_k)\} + \tau^2\Omega_m\{\Omega_j^2 + 4\Omega^2 + (\beta + \Omega_\vartheta)(\Omega_\vartheta + \beta + 2\theta_k)\}\right] \\
&+ \sigma^3\left[(f\Omega_j^2 + K^2V^2 + f4\Omega^2 + f\Omega_\vartheta^2 + 2f\Omega_\vartheta\theta_k)\right. \\
&+ \tau\{(\beta + \Omega_\vartheta)(f\Omega_j^2 + K^2V^2 + 2f\Omega_\vartheta\theta_k) + \Omega_\vartheta(f\Omega_j^2 + K^2V^2) \\
&+ 2\theta_k(f\Omega_{j'}^2 + K^2V^2 + 4f\Omega^2)\} + \tau^2\{K^2V^2\Omega_j^2 + \theta_k(\beta + \Omega_\vartheta)(f\Omega_{j'}^2 + K^2V^2)\} \\
&+ \Omega_m(2\Omega_\vartheta + \theta_k) \\
&+ 2\tau\Omega_m\{\Omega_j^2 + 4\Omega^2 + (\beta + \Omega_\vartheta)(\Omega_\vartheta + \theta_k) + \Omega_\vartheta\theta_k\} + \Omega_m\tau^2\{\theta_k(\Omega_{j'}^2 + 4\Omega^2) \\
&\left. + (\beta + \Omega_\vartheta)(\Omega_j^2 + \beta\theta_k + \Omega_\vartheta\theta_k)\}\right] \\
&+ \sigma^2\left[\Omega_\vartheta(f\Omega_j^2 + K^2V^2 + f\Omega_\vartheta\theta_k) + \theta_k(f\Omega_{j'}^2 + K^2V^2 + f4\Omega^2)\right. \\
&+ \tau\{2K^2V^2\Omega_j^2 + 2\Omega_\vartheta\theta_k(f\Omega_{j'}^2 + K^2V^2)\} + \tau^2K^2V^2\theta_k\Omega_{j'}^2 + \tau\beta\theta_k(f\Omega_{j'}^2 + K^2V^2) \\
&+ \Omega_m(\Omega_j^2 + 4\Omega^2 + \Omega_\vartheta^2 + 2\Omega_\vartheta\theta_k) \\
&\left. + \Omega_m\tau\{(\beta + \Omega_\vartheta)(\Omega_j^2 + 2\Omega_\vartheta\theta_k) + \Omega_j^2\Omega_\vartheta + 2\theta_k(\Omega_{j'}^2 + 4\Omega^2) + \tau^2\theta_k(\beta + \Omega_\vartheta)\Omega_j^2\}\right] \\
&+ \sigma\left[K^2V^2\Omega_j^2 + \Omega_\vartheta\theta_k(f\Omega_{j'}^2 + K^2V^2) + 2\tau K^2V^2\theta_k\Omega_{j'}^2\right. \\
&\left. + \Omega_m\{\Omega_\vartheta(\Omega_j^2 + \Omega_\vartheta\theta_k) + \theta_k(\Omega_{j'}^2 + 4\Omega^2) + \tau\theta_k\Omega_{j'}^2(\beta + 2\Omega_\vartheta)\}\right] + \theta_k\Omega_{j'}^2(K^2V^2 + \Omega_\vartheta\Omega_m) \\
&= 0 \qquad (20)
\end{aligned}$$

These dispersion relation as presents the effect of the simultaneous inclusion of the fine dust particles, finite electron inertia, electrical resistivity, thermal conductivity, viscosity, rotation and magnetic field on the self-gravitational instability of the system for longitudinal propagation with the axis of rotation perpendicular to the magnetic field. The condition of instability and the expression of the critical Jeans wave are obtained from the constant term of (20), which is identical to that of obtained by chhajlani and vyas[8]. We find that is the dispersion relation (20) some terms are multiplied by terms due to the finite electron inertia, but the constant terms is independent of the finite electron inertia.

Hence the condition of instability wellnot be affected by the presence of finite electron inertia, but the growth rate of the system well be changed. It is also find that the condition of instability well not changed by the viscosity and the presence of fine dust particles.

4.2. Transverse mode of propagation $(\boldsymbol{K} \perp \boldsymbol{B})$:

For this case we assume all the perturbations transverse to the direction of the magnetic-field $(i.e. K_x = K, \quad K_z = 0)$.

Thus the dispersion relation (15) becomes

$$\sigma\left[M\{Q_1 M + 4\Omega^2\} + \frac{4\Omega_x^2 V^2 K^2}{a_1}\right] + \Omega_I^2 (M^2 + 4\Omega_x^2) = 0 \quad (21)$$

The dispersion relation (21) shows the influence of finite electrical-resistivity, finite electron-inertia, presence of finite dust particles, rotation, viscosity, magnetic-field and thermal-conductivity on the self-gravitational of infinite homogeneous plasma. In the absence of finite electron inertia (21) reduces to that of Chhajlan and vyas[4] with taking porosity $= 1$ and neglecting permeability in that case. If we ignore finite electron inertia and rotation (21) is similar to those of Chhajlani and Sangvi[3] in the absence of FLR corrections and Hall-effectis that case. The presents results are also similar to those of Prajapati *et al*.[5] in the absence of arbitra-ryradiative heat-loss functions permeability, electrical resistivity and Hall effect in that case.

Now we discuss this dispersion relation (21) is the case of rotation axes parallel and perpendicular to the magnetic field.

4.2.1. Axis of rotation parallel to the magnetic field $(\boldsymbol{\Omega} \parallel \boldsymbol{B})$:

When the axis of rotation is along the magnetic field, we put $\Omega_x = 0 \; and \; \Omega_z = \Omega$ and then the dispersion relation (21) be comes,

$$M\left[M\{\sigma Q_1 + \Omega_I^2\} + 4\sigma\Omega^2\right] = 0 \qquad (22)$$

This dispersion relation shows the combined influence of finite electrical-resistivity, finite electron inertia, resistivity, viscosity, rotation, presence of finite dust particles, and thermal- conductivity on the self-gravitational instability of the hydro-magnetic fluid plasma.

In the absence of finite electrical-resistivity, finite electron inertia, rotation and finite dust particles this dispersion relation reduces to that of chhajlani and parihar[9] with ignoring the effect ofHall current, electrical resistivity and permeability of that case. In the absence of finite electron inertia and finite dust particles.Thus dispersion relation is identical to that obtained by vyas and chhajlani[8] with neglecting the contribution of finite dust particles, Hall current, electrical resistivity and permeability in that case. In the absence of fine dust particles, finite electron inertia, rotation (21) give similar results as are obtained by chhajlani and parihar[9] excluding the effects of Hall current, electrical resistivity, permeability and porosity in that case. The dispersion relation (22) has two independent factors, each representing different modes of propagations.

The first factor of this dispersion relation is stable mode as discussed in the previous case and the second factor of the dispersion relations (22) simplification written as

$$
\begin{aligned}
\tau^2\sigma^7 f + \sigma^6\tau[2f\{1+\tau(\beta+\Omega_\vartheta)\}+\tau(f\theta_k+\Omega_m)] \\
+\sigma^5\left[\tau^2\left(f\Omega_j^2+k^2V^2+4\Omega^2 f\right)+2\tau\Omega_\vartheta f\right. \\
\left.+f\{1+\tau(\beta+\Omega_\vartheta)\}\{1+\tau(\beta+\Omega_\vartheta+2\theta_k)\}+\tau\Omega_m\{2+2\tau(\beta+\Omega_\vartheta)+\tau\theta_k\}\right] \\
+\sigma^4\left[\tau^2\theta_k\left(\Omega_{j'}^2 f+k^2V^2+4\Omega^2 f\right)+\tau\left(\Omega_j^2 f+k^2V^2+8\Omega^2 f+2\Omega_\vartheta\theta_k f\right)\right. \\
+f\{1+\tau(\beta+\Omega_\vartheta)\}\left\{(2\Omega_\vartheta+\theta_k)+\tau\left(\Omega_j^2 f+k^2V^2+\Omega_\vartheta\theta_k+\beta\theta_k\right)\right\} \\
\left.+\Omega_m\left\{\tau^2\left(\Omega_j^2+4\Omega^2\right)+2\tau\Omega_\vartheta+\{1+\tau(\beta+\Omega_\vartheta)\}\{1+\tau(\beta+\Omega_\vartheta+2\theta_k)\}\right\}\right] \\
+\sigma^3\left[f\left(\Omega_\vartheta^2+4\Omega^2\right)\right. \\
+\{1+\tau(\beta+\Omega_\vartheta)\}\left\{\Omega_j^2 f+k^2V^2+2\Omega_\vartheta\theta_k f+\tau\theta_k\left(\Omega_{j'}^2 f+k^2V^2\right)\right\} \\
+\tau\left\{\Omega_\vartheta\left(\Omega_j^2 f+k^2V^2\right)+\theta_k\left(\Omega_{j'}^2 f+k^2V^2+8\Omega^2 f\right)\right\} \\
+\Omega_m\left\{\tau^2\theta_k\left(\Omega_{j'}^2++4\Omega^2\right)+\tau\left(\Omega_j^2+8\Omega^2+4\Omega_\vartheta\theta_k\right)\right. \\
\left.\left.+\{1+\tau(\beta+\Omega_\vartheta)\}\left\{(2\Omega_\vartheta+\theta_k)+\tau\left(\Omega_j^2+\Omega_\vartheta\theta_k+\beta\theta_k\right)\right\}\right\}\right] \\
+\sigma^2\left[\Omega_\vartheta\left(\Omega_j^2 f+k^2V^2+\Omega_\vartheta\theta_k f\right)+\tau\theta_k\left(\Omega_{j'}^2 f+k^2V^2\right)\right. \\
+\theta_k\{1+\tau(\beta+\Omega_\vartheta)\}\left(\Omega_{j'}^2 f+k^2V^2\right)+4\Omega^2 f\theta_k \\
+\Omega_m\left\{\left(\Omega_\vartheta^2+4\Omega^2\right)+\{1+\tau(\beta+\Omega_\vartheta)\}\left(\Omega_j^2+\tau\theta_k\Omega_{j'}^2+2\Omega_\vartheta\theta_k\right)+\tau\Omega_\vartheta\Omega_j^2\right. \\
\left.\left.+\theta_k\left(\Omega_{j'}^2++8\Omega^2\right)\right\}\right] \\
+\sigma\left[\Omega_\vartheta\theta_k\left(\Omega_{j'}^2 f+k^2V^2\right)+\Omega_m\left\{\Omega_\vartheta\left(\Omega_j^2+\Omega_\vartheta\theta_k\right)+\theta_k\Omega_{j'}^2\{1+\tau(\beta+\Omega_\vartheta)\}\right\}\right] \\
+\Omega_\vartheta\theta_k\Omega_{j'}^2\Omega_m \\
=0 \qquad (23)
\end{aligned}
$$

This is Seven degree polynomial equations and shows the combined influence of fine dust particles, viscosity, rotations, magnetic field, thermal conductivity, electron inertia, electrical resistivity and heat-loss functions in the transverse mode of propagation when axis of rotation is parallel to the direction of magnetic field[12-14].

4.2.2. Axis of rotation perpendicular to the magnetic field $(\boldsymbol{\Omega \perp B})$:

In the case of a rotation axis perpendicular to the magnetic field *i.e.* $\Omega_x = 0$ *and* $\Omega_z = \Omega$ Then we get following dispersion relation.

$$\left(M^2 + 4\Omega^2\right)\left\{\sigma Q_1 + \Omega_I^2\right\} = 0 \tag{24}$$

The first factor of (24) gives as

$$\sigma^4\tau^2 + \sigma^3 2\tau\{1 + \tau(\beta + \Omega_\vartheta)\} + \sigma^2\left[\{1 + \tau(\beta + \Omega_\vartheta)\}^2 + 2\tau\Omega_\vartheta + \tau^2 4\Omega^2\right] + 2\sigma\left[\Omega_\vartheta\{1 + \tau(\beta + \Omega_\vartheta)\} + \tau 4\Omega^2\right] + \Omega_\vartheta^2 + 4\Omega^2 = 0 \tag{25}$$

This is four degree polynomial equation and show the combined influence of various parameters. The second factor of dispersion relation (24) simplification written as.

$$\begin{aligned}
&\sigma^5\tau f + \sigma^4[f\{1 + \tau(\beta + \Omega_\vartheta + \theta_k)\} + \tau\Omega_m] \\
&\quad + \sigma^3\left[f(\Omega_\vartheta + \theta_k) + \tau\left\{\Omega_j^2 f + k^2V^2 + \theta_k f(\beta + \Omega_\vartheta)\right\} + \Omega_m\{1 + \tau(\beta + \Omega_\vartheta + \theta_k)\}\right] \\
&\quad + \sigma^2\left[\left(\Omega_j^2 f + k^2V^2 + \Omega_\vartheta\theta_k f\right) + \tau\theta_k\left(\Omega_{j'}^2 f + k^2V^2\right)\right. \\
&\quad \left. + \Omega_m\left\{\Omega_\vartheta + \theta_k + \tau\left\{\Omega_j^2 + \theta_k(\beta + \Omega_\vartheta)\right\}\right\}\right] \\
&\quad + \sigma\left[\theta_k\left(\Omega_{j'}^2 f + k^2V^2\right) + \Omega_m\left\{\Omega_j^2 + \theta_k\left(\tau\Omega_{j'}^2 + \Omega_\vartheta\right)\right\}\right] = 0
\end{aligned} \tag{26}$$

This is five degree polynomial equation and show the combined influence of various parameters, fine dust particles, viscosity, rotations, magnetic field, thermal- conductivity, electrical- resistivity and heat-loss functions in the transverse mode of propagation when axis of rotation perpendicular to the magnetic field.

5. Conclusions

In the present paper, we have analyzed the problem of a self-gravitational instability of a rotating, viscous and magnetized gaseous plasma, considering the effects of a finite electron-inertia, fine dust particles, finite electrical-resistivity, and thermal-conductivity. The general dispersion relation is obtained, which is modified due to the presence of these parameters. This dispersion relation is reduced for longitudinal and transverse mode of propagation, which are further reduced for axes of rotation parallel and perpendicular to the direction of the magnetic-field. We see that the Jeans criterion remains valid but the expression of the Jeans wave is modified. The adiabatic velocity of sound is being replaced by the isothermal are due to thermal-conductivity, increasing the growth rate of instability is all the cases. The stabilizing effect of magnetic-field has been removed by the finite electrical-conductivity. Rotation is effective only in the direction of magnetic field while considering the transverse modeof propagation, where it stabilizes the system. The effectof viscosity is to remove the effect of rotation. In the transverse mode of propagation with axis of rotation parallel to the magnetic-field, we find a gravitating mode influencedby the thermal-conductivity, finite electron-inertia and fine dust particles.

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