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# Magnetohydrodynamic Stability of Self-gravitating Streaming Fluid Cylinder

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**Abstract:** The stability self- gravitating magneto-hydrodynamic of the cylinder flowing fluid was examined. Relation of eigenvalue is derivative. Analytical, the findings were explained, and numerically, they were confirmed. The magnetic and capillary are very strong stabilise, while the streaming is destabilise. The (un)-stable domains are specified. Checked the capillary effect and magnetic fields have an effect just on model's self-gravitating instabilities.

**Keywords:** Magnetohydrodynamic, Stability Self-gravitating, and streaming.

## 1 Introduction

In several published publications, the stability magnetohydrodynamic of the cylindrical fluid conferred of surface tension and exposed to capillary and other influences was documented in several reported works (see [1-5]). The electromagnetic force's effect on capillary instability was investigated by Chandraskhar [6]. For axisymmetric perturbation this was only done when the fluid is confined into a constant magnetic field. Samia S. Elazab [7] examined the stability magnetohydrodynamic of gas jet under the impact of capillary, electromagnetic and inertial forces and surrounded by a flowing radially limited cylinder liquid. The stability magnetohydrodynamic of liquid jets penetrated by dilute medium for (non-) axisymmetric perturbations variations was examined by Radwan [8-14]. He also investigated this work upon considering the effects of other variables. As a result of impact of the forces: self-gravitating, electric, capillary, hasan [15-16] explored the stability of the complete cylindrical fluid enclosed with a languid medium self-gravity permeated with a transversely changing electric field. Hasan [17] examined the cylindrical fluid instability embedded by a transversely shifting electric field for all modes (non)-axisymmetric influenced by an electric, capillary plus self-gravitation forces. Hasan and Abdelkhalek [18] showed the stability magneto-hydrodynamic of a flowing cylindrical fluid. As well as the stability of several cylindrical models was explored as a result of the impact of extra forces for all (non)-axisymmetric perturbations. [22] studied the stability of resistance of magnetohydrodynamic equilibria with alternate areas of constant and non-uniform pressure. [23] discussed the optimal magnetohydrodynamic characteristics of axisymmetric balance magnetoplasma formations of three rings current-carrying in the Galatea trapping depending on the plasma pressure. [24] studied the electrically conductive fluid instability under the effect of a transversal magnetic field created by two parallel plates. The aim of this paper is investigate a cylindrical flowing fluid magneto-hydrodynamic stability, demonstrating the impact of capillary force and a flowing fluid on the magnetic stabilization, as well as magnetic fields and capillary upon extant models' self-gravitational destabilization. For all (non)-axisymmetric modes of perturbations, the conclusion would be confirmed numerically and theoretically.

## 2 The problem's description

Assume the homogenous cylindrical non-viscid incompressible fluid with radius $R_0$ encircled by the negligible slow-moving medium. The model assumed to stream uniformly with velocity

$$\underline{u}_0 = (0,0,U) \tag{1}$$

As well as permeated by the magnetic fields inwardly and outwardly

$$\underline{H}_0 = (0,0,H_0)\,,\ \ \underline{H}_0^{ex} = (0,0,\alpha H_0). \tag{2}$$

Where U is the fluid's (constant) velocity, $H_0$ is the magnetic field's intensity of the fluid and $\alpha$ serveral parameter, the variables of $\underline{u}_0$ , $\underline{H}_0$, $\underline{H}_0^{ex}$ are analysed along the coordinates (r,$\varphi$,z) with the z-axis coincident with cylinder's axis as

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shown in a figure (1.1). The fluid impacted by the group effects of a self-gravitating, inertial, magnetic, and capillary forces.

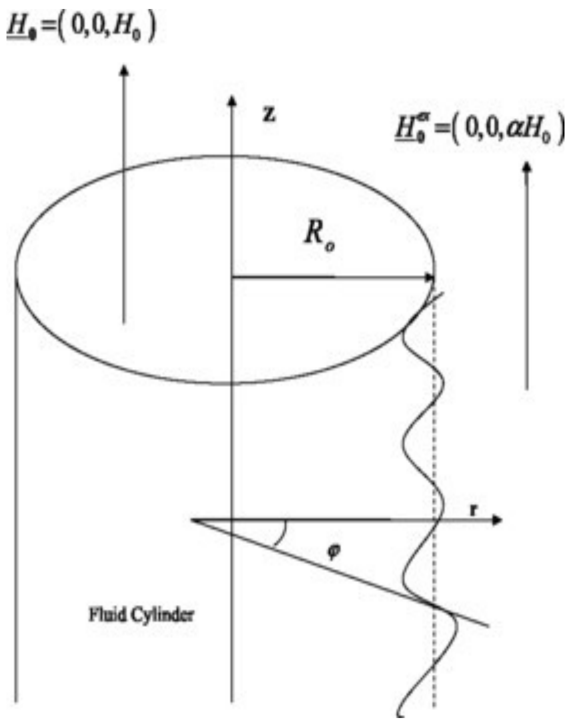


Fig. 1.1: self-gravitation MHD cylindrical Fluid sketch

The study's basic equations are listed below.

$$\rho\left[\frac{\partial \underline{u}}{\partial t} + (\underline{u}\,.\nabla)\underline{u}\right] = -\nabla P + \rho\nabla V + \frac{\mu}{4\pi}\left(\nabla \wedge \underline{H}\right)\wedge \underline{H} \quad (3)$$

$$\nabla.\underline{u} = 0 \quad (4)$$

$$\nabla.\underline{H_0} = 0 \quad (5)$$

$$\frac{\partial \underline{H_0}}{\partial t} = \nabla\wedge\left(\underline{u}\wedge\underline{H}\right) \quad (6)$$

$$\nabla^2 V = -4\pi G\rho \quad (7)$$

$$P_s = T(\nabla.\underline{N_s}) is\ the\ curves\ pressure\ owing\ to\ the\ capillary\ force. \quad (8)$$

$$\underline{\mathrm{N}}_s = \nabla F(\mathrm{r},\varphi\ ,\mathrm{z}\ ;\mathrm{t}) /\ |\nabla F\ | \quad (9)$$

Then $F(\mathrm{r},\varphi\ ,\mathrm{z}\ ;\mathrm{t}) = 0$ (10)

Is equation of the boundaries surface at time t, $\underline{N_s}$ is an external vector unit normal to the surface ,T is hydrostatic pressure , and $p_s$ is pressure due bending. For the languid medium surround it.

$$\nabla.\underline{H}^{ex} = 0 \quad (11)$$

$$\nabla\wedge\underline{H}^{ex} = 0 \quad (12)$$

$$\nabla^2 V^{ex} = 0 \quad (13)$$

Where P, $\underline{u}$, $\rho$ denote the static pressure, speed vector, mass density for fluid, respectively,$\underline{H}$ , $\mu$ denote the strength coefficient and magnetic permeability , $V^{ex}$, $V$denote the self-gravitational potentials outside and inside the cylinderical fluid , respectively.

## 3 Undisturbed State

The essential quantities of such a condition are determined by studying the basic equations. By combining equations (1) and (3), you get

$$\nabla\left(\rho V_0 - P_0 - \frac{\mu}{8\pi}H_0^2\right) = 0 \quad (14)$$

By integration we get

$$P_0 = \rho V_0 - \frac{\mu}{8\pi} H_0^2 + C \quad (15)$$

Where C can be defined as a constant of integration.
The surface pressure owing to capillary force is calculated as follows:

$$P_{0s} = {}^{T}/_{R_0} \quad (16)$$

The gravitational potential satisfies $V_0$, $V_0^{ex}$ for the unperturbed state

$$\nabla^2 V_0 = -4\pi G\rho \quad (17)$$

$$\nabla^2 V_0^{ex} = 0 \quad (18)$$

In cylindrical symmetries ($\frac{\partial}{\partial\emptyset} = 0, \frac{\partial}{\partial z} = 0$), the non-singular solution of relations (17), (18) are given by

$$V_0 = -\pi G\rho r^2 + C_1 \quad (19)$$

$$V_0^{ex} = C_2 \ln r + C_3 \quad (20)$$

Where $C_1$, $C_2$ and $C_3$ are integral constants can calculate by application the following conditions.

*(i) At r=R0 and C1=0, the self-gravitational potential v and its derivatives must continuously pass through the undisturbed surface.*

From above conditions we get

$$C_2 = -2\pi G\rho R_0^2 \quad (21)$$

$$C_3 = -\pi G\rho R_0^2 + 2\pi G\rho R_0^2 \ln R_0 \quad (22)$$

Therefore

$$V_0 = -\pi G\rho r^2 \quad (23)$$

$$V_0^{ex} = -\pi G\rho R_0^2 \left[1 + 2\ln {}^{r}/_{R_0}\right] \quad (24)$$

*$(ii)$ At r =$R_0$, the total pressure across the boundary surface must be balanced, and the fluid pressure distribution in the non-turbulent condition is given by*

$$P_0 = {}^{T}/_{R_0} + \pi G\rho^2 (R_0^2 - r^2) + \frac{\mu}{8\pi}(\alpha^2 - 1)H_0^2 \quad (25)$$

## 4 Perturbation state

Every physical quantity Q(r, $\varphi$,z;t) because the initial flow state is turbulent, can be expressed as

$$Q(r,\varphi,z;t) = Q_0(r) + \in(t) Q_1(r,\emptyset,z;t) \quad (26)$$

Where Q stand for $P, u, V, V^{ex}, H, H^{ex}$ *and* $N_s$ while $Q_0$ refer to the unaffected amount and $Q_1$ is a minor increase in $Q$ owing to perturbations. Believe a minor deviation from an incompressible fluids undisturbed. So, we suppose the curved surface can be expressed as

$$r = R_0 + R_1 + \cdots \quad (27)$$

With $R_1 = \in(t) exp\big(i(kz + m\emptyset)\big)$ And $\in(t) = \in_0 \, exp(\sigma t)$ (28)

Where $R_1$ is the height of the surface wave determined from the undisturbed position, k(real number) is the number of waves propagating ,m(integer)is the transient elastic number, ∈(t) is the perturbation's magnitude ,and σ is the temporal . Using expansion (26), the basic equations (3)-(13) become

$$\rho\left(\frac{\partial \underline{u}_1}{\partial t} + (\underline{u}_0 \cdot \nabla \underline{u}_1)\right) = -\nabla P + \rho\nabla V_1 + \frac{\mu}{4\pi}(\underline{H}_0 \cdot \nabla)\underline{H}_1 - \frac{\mu}{4\pi}\nabla(\underline{H}_0 \cdot \underline{H}_1) \quad (29)$$

$$\nabla \cdot \underline{u}_1 = 0 \quad (30)$$

$$\nabla \cdot \underline{H}_1 = 0 \quad (31)$$

$$\frac{\partial \underline{H}_1}{\partial t} = (\underline{H}_0 \cdot \nabla)\underline{u}_1 - (\underline{u}_0 \cdot \nabla)\underline{H}_1 \quad (32)$$

$$\nabla^2 V_1 = 0 \quad (33)$$

$$P_{1s} = (\frac{-T}{R_0^2})(R_1 + \frac{\partial^2 R_1}{\partial \emptyset^2} + R_0^2(\frac{\partial^2 R_1}{\partial z^2})) \tag{34}$$

$$\nabla \cdot \underline{H}_1^{ex} = 0 \tag{35}$$

$$\nabla \wedge \underline{H}_1^{ex} = 0 \tag{36}$$

$$\nabla^2 V_1^{ex} = 0 \tag{37}$$

The linearized variable $Q_1(r, \varphi, z; t)$ by using the linear perturbation approach may be represented

$$Q_1 = q_1(r) exp(\sigma t + i(kz + m\varphi)) \tag{38}$$

By using expansion (38), formulas (33) and (37) give the ordinary differential equation of second-order

$$\left(\frac{1}{r}\right)\frac{d}{dr}\left(r\frac{dq_1}{dr}\right) - \left(\frac{m^2}{r^2} + k^2\right)q_1(r) = 0 \tag{39}$$

Where $q_1$ stands for $V_1(r)$ *and* $V_1^{ex}(r)$ . Apart from the unique solutions, the solution of equation (39) is defined in terms of the ordinary Bessel functions of imaginary arguments for the situation under study. The resolutions of eqs. (33) and (37) are provided by

$$V_1 = AI_m(kr) exp(\sigma t + i(kz + m\emptyset) \tag{40}$$

$$V_1^{ex} = BK_m(kr) exp(\sigma t + i(kz + m\emptyset)) \tag{41}$$

Here A, B are integral constants that can be calculated and $I_m(kr)$ *and* $K_m(kr)$ are the Bessel correction function of the first and second kinds of order m, respectively.

By using expansion (38) with equation (29), obtain

$$(\sigma + ikU)\underline{u}_1 - \frac{i\mu k}{4\pi\rho} H_0 \underline{H}_1 = -\nabla \Pi_1 \tag{42}$$

Where $\Pi_1 = \frac{P_1}{\rho} - V_1 + \frac{\mu}{4\pi\rho}(\underline{H}_0 \cdot \underline{H}_1)$ (43)

Also, equation (32) yields

$$\underline{H}_1 = \frac{ikH_0}{(\sigma + ikU)} \underline{u}_1 \tag{44}$$

By combining equations (42) and (44) we get

$$\underline{u}_1 = \frac{-(\sigma + ikU)}{((\sigma + ikU) + \Omega_A^2)} \nabla \Pi_1 \tag{45}$$

Where $\Omega_A = (\frac{\mu^2 k^2 H_0{}^2}{4\pi\rho})^{\frac{1}{2}}$ (46)

The deviation of both equations (45) is the following equation (38):

$$\nabla^2 \Pi_1 = 0 \tag{47}$$

Therefor equation (31) implies that the magnetic field density $H_1^{ex}$ in the case of perturbation may be estimated using a scalar function, say $\Psi_1^{ex}$, which including

$$H_1^{ex} = \nabla \Psi_1^{ex} \tag{48}$$

Also, evaluating the difference on both sides of the equation (48) we get

$$\nabla^2 \Psi_1^{ex} = 0 \tag{49}$$

The spatial dependence of the equation (38) for (47) and (49) is similar to the procedure for solving differential equations (33) and (37), and its solving equations (47) and (49) can be found.so the non-singular solutions of $\Pi_1(r, \varphi, z; t)$ and $\Psi_1^{ex}$ is

$$\Pi_1 = C_4 I_m(kr) exp(\sigma t + i(kz + m\varphi)) \tag{50}$$

$$\Psi_1^{ex} = C_5 K_m(kr) exp(\sigma t + i(kz + m\varphi)) \tag{51}$$

Where C 4 and C 5 are integral constant that must be found when governing equations are applied.

Relation (34) and (28) are using to determine the surface pressure $P_{1s}$ in the perturbation state owing the capillary force by the way

$$P_{1s} = \left(\frac{-T}{R_0^2}\right)[1 - m^2 - x^2]R_1 \tag{52}$$

(Dimensionless number of longitudinal waves is $x = kR_0$).

## 5 Boundary condition

Resolution of the fundamental equation (3)-(13) in an undisturbed region defined by (15) and (19) and in a disturbed region defined by (40), (41), (50), and, (51) meet the appropriate it is a critical boundary layer. We want to apply these boundary conditions to the perturbation $r = R_0 + \in (t)R_1 + \cdots$ of the boundary surface of the orbit $r = R_0$ must satisfy appropriate boundary layers. These conditions could be given in terms:

$(i)$ *Conditions self-gravitating*

Across the altered fluid interface $r = R_0 + \in (t)R_1 + \cdots$ at unperturbed boundary $r = R_0$ , the gravitation potential and its derivatives must be continuous.

$$V_1 + R_1 \frac{\partial V_0}{\partial r} = V_1^{ex} + R_1 \frac{\partial V_0^{ex}}{\partial r} \tag{53}$$

$$\frac{\partial V_1}{\partial r} + R_1 \frac{\partial^2 V_0}{\partial r^2} = \frac{\partial V_1^{ex}}{\partial r} + R_1 \frac{\partial^2 V_0^{ex}}{\partial r^2} \tag{54}$$

By substituting from equations (23), (24), (26), (40), and, (41) into equations (53) and (54) we obtain

$$AI_m(x) - BK_m(x) = 0 \tag{55}$$

$$AI'_m(x) - BK'_m(x) = 4\pi G\rho({}^{R_0}/_{x}) \tag{56}$$

From which we get

$$A = 4\pi G\rho R_0 K_m(x) \tag{57}$$

$$B = 4\pi G\rho R_0 I_m(x) \tag{58}$$

*(ii) Condition kinematics*

This condition states that the normal component of the velocity vector u corresponds to the required velocity of the particle at the interface (27) of the orbital plane r = $R_0$. It's become

$$\underline{u}_{1r} = \frac{\partial R_1}{\partial t} + U\frac{\partial R_1}{\partial z} \tag{59}$$

Using equations (27), (45), and,(50) for the condition (59)we get

$$C_4 = ((\sigma + ikU)^2 + \Omega_A^2)(R_0/xI'_m(x)) \tag{60}$$

$(iii)$ *Condition of magnetodynamics*

There is no normal component of the magnetic field of the different entire fluid perturbation interface r=$R_0$. That is to say,

$$\underline{N_S} \cdot \underline{H} - \underline{N_S} \cdot \underline{H}^{ex} = 0 \text{ at } r = R_0 \tag{61}$$

Form which, we get

$$C_5 = \frac{i\alpha H_0}{K'_m(x)} \tag{62}$$

## 6 Eigenvalue Relation

The suitable dynamic conditions are used here as a compliance conditions. The velocity of the particles at the interface (24) of the orbital plane r =$R_0$ must be consistent with the normal component of the velocity vector u. Given this condition

$$P_1 + R_1 \frac{\partial P_0}{\partial r} + \frac{\mu}{4\pi}(\underline{H}_0 \cdot \underline{H}_1) - \frac{\mu}{4\pi}(\underline{H}_0 . \underline{H}_1)^{ex} = P_{1s} \tag{63}$$

From equation (43) the condition (63) become

$$\rho(\Pi_1 + V_1) = P_{1s} - R_1 \frac{\partial P_0}{\partial r} + \frac{\mu}{4\pi}(\underline{H}_0 . \underline{H}_1)^{ex} \tag{64}$$

Using equations (25), (28), (40), (50), and, (52) we get

$$(\sigma + ikU)^2 = \frac{\mu H_0^2}{4\pi G\rho}\left[\alpha^2 x^2 \frac{K_m(x) I'_m(x)}{I_m(x) K'_m(x)} - x^2\right] + 4\pi G\rho \frac{x I'_m(x)}{I_m(x)}\left[K_m(x) I_m(x) - \frac{1}{2}\right]$$

$$+ \frac{T}{\rho R_0^3}\left(\frac{x I'_m(x)}{I_m(x)}\right)(1 - m^2 - x^2) \tag{65}$$

## 7 Limiting cases

The dispersing equation of a fluid cylinder acting on magnetic, capillary, inertia, and self-gravitational forces is desired (65), it contain the natural quantity$(\frac{T}{\rho R_0^3})^{\frac{1}{2}}$ and also, $(\frac{\mu H_0^2}{4\pi\rho R_0^2})^{\frac{1}{2}}$ together with$(4\pi G\rho)^{\frac{-1}{2}}$ , each as time units. The last amount highly fascinating and serve an importance purpose since we want to rewrite relation (65) in a dimensionless version because $\sigma$ has a unit $(time)^{-1}$. The above situation is similar to Chandrasekhar's [5] axisymmetric (m=0) perturbation of a cylinder non-streaming fluid. It relates the growth rate $\sigma$ with the first and second kinds Bessel-modified functions $I_m(x)$ and $K_m(x)$ of order(m) and their variants, the wave longitudinal numeral x, and also, $R_0, \alpha, G, \mu, H_0, \rho$ are radius of a cylinder, the magnetic field parameter, self-gravity constant, the coefficient of the magnetic permeability, the fundamental magnetic field intensities, the fluid density, respectively. Since the eigenvalue relation (65) is general relation can be obtained as limiting cases from it.

In case $(U = 0, \alpha = 0, H_0 = 0, G = 0, and, m = 0)$. Equation (65) reduce to

$$\sigma^2 = \frac{T}{\rho R_0^3}\left(\frac{xI_1(x)}{I_0(x)}\right)(1 - x^2) \quad (66)$$

This relation is the same relation as which Rayleiyh [1] found for the capillary instability of a complete liquid jet in a space.

Putting $(\alpha = 0, T = 0, H_0 = 0, U = 0, and\ m = 0)$. Equation (65) degenerates to

$$\sigma^2 = 4\pi G\rho\left(\frac{xI_1(x)}{I_0(x)}\right)[K_0(x)I_0(x) - \tfrac{1}{2}] \quad (67)$$

This relationship is consistent, and derive the Chandrasekhar and Fermi [2]
If we let $(\alpha = 1, U = 0, T = 0, and\ m = 0)$ the relation (65) yields

$$\sigma^2 = 4\pi G\rho\left(\frac{xI_1(x)}{I_0(x)}\right)\left[K_0(x)I_0(x) - \tfrac{1}{2}\right] - \frac{\mu H_0^2}{4\pi G\rho R_0^2}\left(\frac{x}{I_0(x)K_1(x)}\right) \quad (68)$$

Chandrasekhar [6] proved this relationship to investigate the influence of a fluid jet's self-gravitation instability.

In case $(\alpha = 0, H_0 = 0, U = 0, and\ m = 0)$ Equation (65) becomes

$$\sigma^2 = 4\pi G\rho\left(\frac{xI_1(x)}{I_0(x)}\right)\left[K_0(x)I_0(x) - \tfrac{1}{2}\right] + \frac{T}{\rho R_0^3}\left(\frac{xI_1(x)}{I_0(x)}\right)(1 - x^2) \quad (69)$$

Abromowiz and Stegun [8] discovered this relationship when investigating the capillary gravitodynamic stability of two fluids interfaces when the density of the outer fluid is vanished.

## 8 Numerical discussions

Within the trendy case of the flowing cylinder fluid is acted upon by the consequences of the group of forces are magnetic, self-gravitation, capillary. It not easy to find in the analysis of (un-)stable areas, although we can define them through numeric arguments since the eigenvalue relation (66) is stated in standard form. Moreover, we identify the impacts of a magnetic field among a fixed capillary upon a self-gravitating force through this discussion, which may be done by computing the dimensionless governing equation

$$\frac{(\sigma + ikU)^2}{4\pi G\rho} = \frac{x\grave{I}_m(x)}{I_m(x)}\left(K_m(x)I_m(x) - \frac{1}{2}\right) - M\left(\frac{x\grave{I}_m(x)}{I_m(x)}(1 - m^2 - x^2)\right) + \gamma(\alpha^2 x^2\frac{K_m(x)\grave{I}_m(x)}{I_m(x)\grave{K}_m(x)} - x^2)$$

In case m=0

$$\sigma^* = \sqrt{\left(\left(x\frac{I_1(x)}{I_0(x)}\left(K_0(x)I_0(x) - \frac{1}{2}\right)\right) + M\left(x\frac{I_1(x)}{I_0(x)}(1 - x^2)\right) - Nx^2\left(\left(\alpha^2\frac{K_0(x)I_1(x)}{K_1(x)I_0(x)} + 1\right)\right)\right)} + U^*$$

through the computer for various parameters of $M = \frac{T}{4\pi G\rho^2 {R_0}^2}$ , $U^* = \frac{-ikU}{(4\pi G\rho)^{\frac{1}{2}}}$ , $N = \frac{\mu}{16\pi^2 G}(\frac{H_0}{\rho R_0})^2$

And range 0 ≤x≤3, the numeric values of $\sigma^* = \frac{\sigma}{(4\pi G\rho)^{\frac{1}{2}}}$ referring to the unstable regions and $\omega^* = \frac{\omega}{(4\pi G\rho)^{\frac{1}{2}}}$ referring to the stable regions, the numerical results are represented graphically.

For $N = 0, 0.1, 0.2, 0.4$ , and ,0.8 corresponding to $U^* = 0$ , $M = 0.1$. The unstable domains have been discovered to be 0 <x <1.8342, while the stable domains neighboring are 1.8342 ≤x < ∞ , 0 ≤x < ∞, 0 ≤x< ∞,0 ≤x< ∞, and 0 ≤x<∞, show figure (2). Where $x_c = 1.8342$ is the transition from unstable to stable domain and the equivalences that correspond to the limit states stability.

For $N = 0,0.1,0.2,0.4$ , *and* ,0.8 corresponding to $U^* = 0$ , $M = 0.4$ . The unstable domains have been discovered to be 0 <x <1.4122 and 0 <x< 0.9034, while the stable domains neighboring are 1.4122 ≤x< ∞, 0 ≤x< ∞, 0 ≤x< ∞, 0 ≤x<∞, and 0.9034 ≤x< ∞, see figure (3) where $x_c = 1.4122$ *and* $0.9034$ .

For $N = 0,0.1,0.2,0.4$ , *and* ,0.8 corresponding to $U^* = 0$ , $M = 0.9$. The unstable domains have been discovered to be 0 <x <1.3318 and 0 <x <0.9275, while the stable domains neighboring are 1.3318 ≤x< ∞, 0.9275 ≤x< ∞,0 ≤x<∞, 0≤x<∞, and 0 ≤x< ∞,see figure (4), where $x_c = 1.3318$ *and* $0.9275$.

For $N = 0,0.1,0.2,0.4$ , *and* ,0.8 corresponding to $U^* = 1.1$ , $M = 0.4$ . Of this unstable region are 0 <x <1.443, and 0 <x< 0.9473 , while the stable domains neighboring are 1.443 ≤x< ∞, 0.9473 ≤x< ∞, 0≤x<∞,0 ≤x< ∞, and 0≤x<∞,see figure (5) where $x_c = 1.443$ *and* $0.9473$.

For $N = 0,0.1,0.2,0.4$ , *and* ,0.8 corresponding to $U^* = 1.2$ , $M = 0.4$ of this unstable regions are 0<x <1.4442, and 0<x< 0.9475, while the stable domains neighboring are 1.4442≤x<∞, 0.9475≤x< ∞, 0≤x<∞,0 ≤x< ∞, and 0≤x<∞,see figure (6), where $x_c = 1.4442$ *and* $0.9475$.

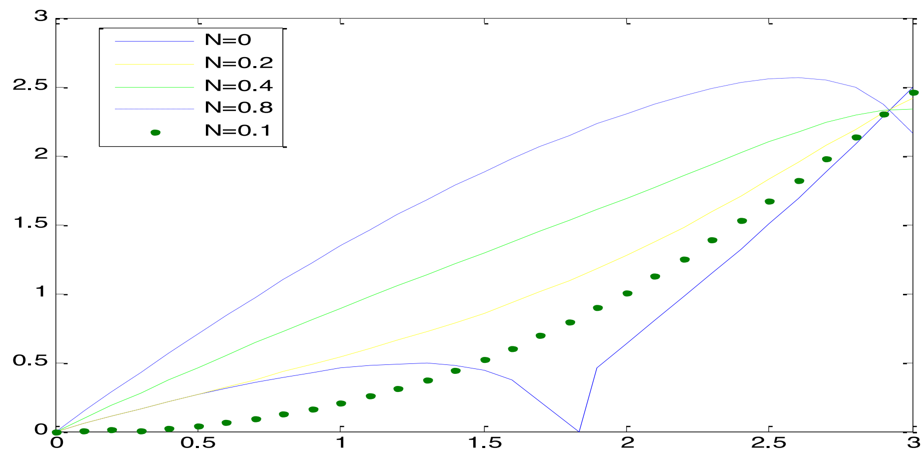


**Fig. 2:** Stability MHD of a cylinder fluid permeated by a uniform field.

For $\sigma^* = \frac{\sigma}{(4\pi G\rho)^{\frac{1}{2}}}$ , M=0.1, $U^* = 0$, and $\alpha = 1.4$.

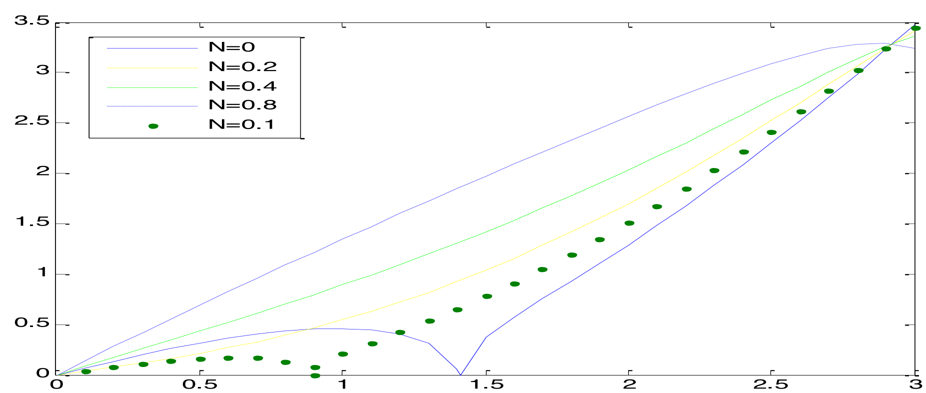


**Fig. 3:** Stability MHD of a cylinder fluid permeated by a uniform field

For $\sigma^* = \frac{\sigma}{(4\pi G\rho)^{\frac{1}{2}}}$ , M=0.4 , $U^* = 0$,and $\alpha = 1.4$.

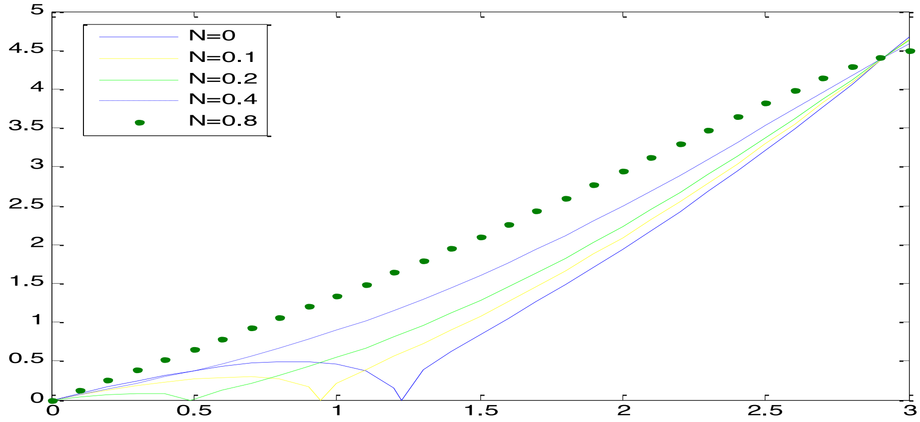


**Fig.4:** Stability MHD of a cylinder fluid permeated by a uniform field

For $\sigma^* = \frac{\sigma}{(4\pi G\rho)^{\frac{1}{2}}}$ , M=0.9 , $U^* = 0$, and $\alpha = 1.4$

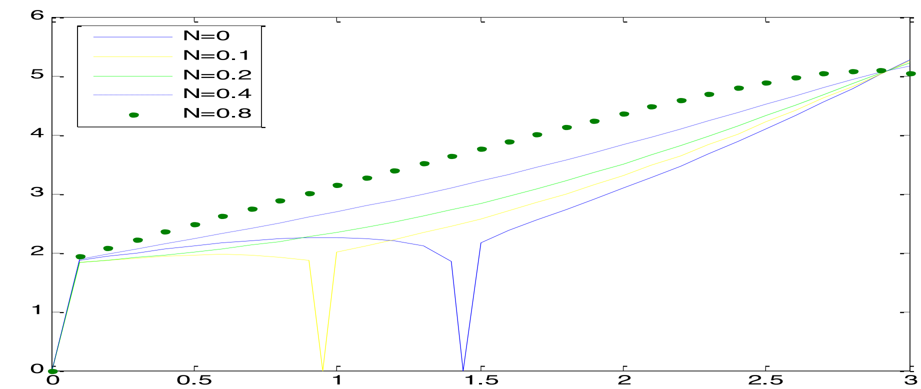


**Fig. 5:** Stability MHD of a cylinder fluid permeated by a uniform field

For $\sigma^* = \frac{\sigma}{(4\pi G\rho)^{\frac{1}{2}}}$ , M=0.4, $U^* = 1.1$, and $\alpha = 1.4$

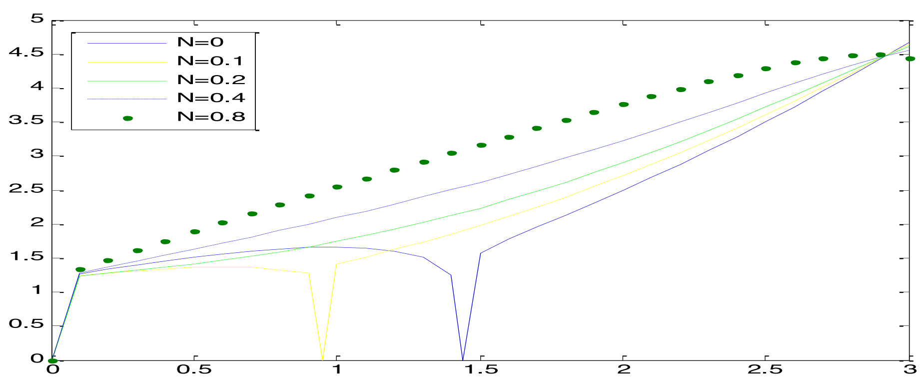


**Fig. 6:** Stability MHD of a cylinder fluid permeated by a uniform field

For $\sigma^* = \frac{\sigma}{(4\pi G\rho)^{\frac{1}{2}}}$ , M=0.4, $U^* = 1.2$, and $\alpha = 1.4$

## 9 Conclusion

From numerical discussion, we conclude that

**(1)** The unstable domains are decreased as N value increases for a same value of U*. This implies that the magnetic field's impact has a stabilizing effect.

**(2)** Increasing N with constant capillary force (M) decrease the unstable domains and increase the stable domains, indicating that the magnetic force's influence on the model is stabilizing.

**(3)** On the model, the capillary force has a significant stabilizing effect.

**(4)** It is discovered that as U* values increase, the unstable domains increase for the same values of N. This explains that the streaming effect destabilizes for all wave lengths, short and long.

**(5)** The unstable domain grows with rising M values for the same value of N, indicating the capillary force has a large destabilizing effect upon model's self-gravitation destabilization.

**(6)** The magnetic has a stabilizing impact on the model's self-gravitating instabilities.

## Conflict of interest

The authors declare that there is no conflict regarding the publication of this paper.

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