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Distribution Of Ions, Electrons And Dust Particles In Partially Ionized And Magnetized Molecular Clouds.

Palash Borah[1] and A. C. Borah[2]
[1]Research Scholar Singhania University,Rajasthan.

[2]NECRD IGNOU, Sixmile,Guwahati,Assam-781022

AbstractMolecular Clouds are relatively dense clouds in the region of interstellar matter where hydrogen gas primarily in molecular form. The interstellar clouds are called dense molecular clouds which contains a high fraction of molecules. Starforming interstellar clouds are partially ionized by different ionizing sources and the constituent particles viz-electron,ions and dust particles do not follow Boltzmanian distribution.We present here the Non-Boltzmanian distribution of such particles of electron ion and dust particles.

Key words:-Interstellar Clouds, Interstellar Space, Molecular clouds.

Introduction:- Interstellar clouds are the ionized and neutral gas both in atomic and molecular forms with the varying concentration in the entire interstellar space.Besides the gas particles there are also minute solid particles of undetermined structure and composition which are more popularly called interstellar grains or interstellar dust .The gas and dust particles pervade the vast interstellar space also there are cosmic rays bombarding the entire regions of interstellar space and a general magnetic field pervading the space. The interaction of cosmic rays with the galactic magnetic field and various physical and dynamical processes in ionized gas (Goertz and Ip 1948,Walch et al. 1995).The constituent particles of interstellar clouds viz- electrons and ions do not follow Boltzmanian distribution. The distribution of such particles are very important to study the various characteristics of interstellar clouds and also the role of distribution of electron and ions can give us the information of various characteristics of starforming clouds.

Equation of Motion:-

To calculate the distribution function for different species in the system of a partially charged dusty plasma with neutral drag force, we consider a multi fluid system with charged dust grains, neutral dust grains, electron, ions and neutral gases. The number density ,size, mass, charge and temperature of

charge dust grains are assumed respectively to be n_{dc},a,m_d ,g_d, T_d and the corresponding quantities for neutral grains are respectively n_{dn},a,m_d,0,T_d. Furthermore for an electron and ion, we assume then density, charge, mass and temperature to be n_e,e,m_e ,T_e and n_i',e, m_i and T_i respectively . The quantities which very with the perturbation of the form $\int \exp(ikx - i\omega t)$ *can be witten as for example as* $n_e=n_{eo}+n_e$, $n_i=n_{io}+n_i$. *It is also noted that dust grain and grain are used to mean one and the* *same. Assuming a complete uniformity in the gravitatioelectrostatic fluid distribution, thr equation of continuity for electrons can be written as –*

$$\frac{\partial n_e}{\partial t}+\nabla.(n_e V_e)=0 \qquad .....(1)$$

Here $V_e=v_{eo}+v_e$ where the first term is the equllibrium state part and the second term is the result of the perturbation. Since, before the fluctuation, the system was in the state of equilibrium $v_{eo}=0$ and since the fluctuation is of the form $\int \exp(ikx - i\omega t)$, the operation in the above equations can be substituted as $\frac{\partial}{\partial t}=-i\omega$ and $\nabla=ik$. Thus linearizing the above equation one obtain-

$$\frac{\partial n_e}{\partial t}=\nabla(n_e v_e)=0$$

$$-i\omega n_e+ikn_{eo}v_e=0 \qquad .....(2)$$

$$V_e=\frac{\omega}{k}\frac{n_e}{n_{eo}}$$

The equation of motion for electron is –

$$\frac{e}{m}[\nabla\varphi+\frac{\partial A}{\partial t}]-C_e^2\frac{\nabla n_e}{n_{eo}}-v_{en}v_e=0 \qquad ....(3)$$

$Here\ \gamma_{en}$ is the bineary collision rate of momentum transfer from electrons to the neutral particles and given by $\vartheta_{en}=\sigma C_e n_n$ where σ is the cross-section of the collision of the electron with the neutral particle, C_e is the thermal velocity of electrons. n_d is the number density of the neutral components and φ is the electrostatic potential.

The equation of continuity and equation of motion for charge dust grains can be written as-

$$\frac{\partial n_{dc}}{\partial t}+\nabla.(v_{dc}n_{dc})=0 \qquad ....(4)$$

And $\frac{\partial V_{dc}}{\partial t}=-\frac{q_d}{m_d}(\nabla\varphi+\frac{\partial A}{\partial t})-\nabla\psi-v_{cn}(v_{dc}-v_{dn})$ ....(5)

Where ψ is the gravitational potential, A is magnetic potential, ν_{cn} is the binary collisional rate of momentum transfer from charge dust grains and can be given by $\nu_{cn} \backsim \pi a^2 n_{dno} C_{td}$ and the opposite quantity ie, the collisional rate of momentum transfer from neutral dust grains to charge dust grains can be written as $\nu_{cn} \backsim \pi a^2 n_{dco} C_{td}$ where C_{td} corresponds to the thermal velocity of dust grains and πa^2 geometrical cross-section.

Calculation of Distribution:-

Linearizing (2)in the same way as for (3)and substituting V_e one obtain-

$$\frac{\boldsymbol{e}}{\boldsymbol{m}}[ik\varphi-i\omega A]-iC_e^2 k\frac{n_e}{n_{eo}}-\vartheta_{en}\frac{\omega}{k}\frac{n_e}{n_{eo}}=0 \qquad ....(6)$$

$\frac{e}{m}$ i(k$\varphi - \omega A$)-$\frac{n_e}{n_{eo}}$(iC_e^2k +ϑ_{en} $\frac{\omega}{k}$) =0

$\frac{n_e}{n_{eo}}$(iC_e^2+$\frac{\omega}{k}$ ϑ_{en})=$\frac{e}{m}$ i(kφ-ωA)

n_e(iC_e^2k+$\frac{\omega}{k}$ ϑ_{en})=i$\frac{e}{m_e}$ n_{eo}(kφ-ωA)

$$n_e = \frac{i\frac{e}{m}n_{eo}(k\varphi - \omega A)}{iC_e^2 k + \frac{\omega}{k}\vartheta_{en}}$$

$$n_{e=}n_{eo}\frac{i\frac{e}{m_e}\frac{1}{\vartheta_{en}}(k\varphi - \omega A)k^2}{\omega + i(\frac{C_e^2 k^2}{\vartheta_{en}})}$$

n_e =$n_{eo}\, i\frac{\frac{e}{m_e}\left(\frac{1}{\vartheta_{en}}\right)(\varphi - \frac{\omega}{k}A)k^2}{\omega + i(C_e^2 k^2/\vartheta_{en})}$ ....(7)

Similarly for ion,

$n_{i=}n_{eo}\, i\frac{\frac{e}{m}\left(\frac{1}{\vartheta_{in}}\right)(\varphi - \frac{\omega}{k}A)k^2}{\omega + i(C_i^2 k^2/\vartheta_{in})}$ ....(8)

Here ϑ_{in} is the bineary rate of momentum transfer from ions to neutral particles and is given by

$\vartheta_{in=}\sigma C_i n_n$ where C_i is the thermal velocity of ions. The rate of change of the unperturbed parts of the quantities is considered to be zero.

From equation (4) using the conditions,

$\frac{\partial n_{dco}}{\partial t}$ =, v_{dco} =0 and $n_{dco} \gg n_{dc}$ we obtain-

v_{dc}=$\frac{\omega n_{dc}}{k n_{dco}}$ ....(9)

And from (5) we obtain-

$v_{dc}(v_{cn}$-iω)= -$\frac{q_d}{m_d}$(ik$\varphi - i\omega A$)$-ik\psi$+$v_{cn} v_{dn}$ ....(10)

For neutral dust grains ie, charge=0 and using $\frac{\partial n_{dno}}{\partial t}$=0, v_{dno} =0 and $n_{dno} \gg n_{dn}$ the above equation yield,

$v_{dn} = \frac{k}{\omega}\psi$ ....(11)

Where n_{dno} and n_{dco} respectively denote the density population of the neutral dust grains and charged dust grains.

Thus we obtain $n_{dn} = \frac{k^2}{\omega^2} n_{dno}\ \psi$ ....(12)

$$n_{dc} = \frac{n_{dco}\ [\psi + \frac{q_d}{m_d}\left(1 + i\frac{v_{cn}}{\omega}\right)^{-1}(\varphi - \frac{\omega}{k}A)]}{\omega^2/k^2} \qquad \text{................(13)}$$

Result and Discussion:-

Here we have calculated the electron and ion distribution. Thus the expression (5) and (6) give the perturbed densities of electrons and ions respectively. Which clearly depend on the collision rate of these species with the neutral component.It is also interesting to note that the perturbed number density of charged dust grains is not only a fraction of the electric potential(φ) but also a fraction of the gravitational potential (ψ), starting with uniformdensity of charged dust grains which has been created owing to the absorption of charges by dust-grains from plasma environment,the density increases with an increase in the gravitational field potential.

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