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Calculation of Particle Distribution in Partially Ionized Molecular Clouds

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Abstract:
A relatively dense cloud of interstellar matter where hydrogen gas is primarily in molecular form are referred as molecular clouds. The interstellar clouds are called dense molecular clouds which contains a high fraction of molecules. Star forming interstellar clouds are partially ionized by different ionizing sources and the constituent particles viz-electron and dust do not follow Boltzmanian distribution. We present here the Non-Boltzmanian distribution of such particles viz electron and ions.

Keywords: *Interstellar Clouds, Interstellar Space, Molecular clouds.*

1. 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 star forming clouds.

1.1. 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 written 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 gravitation-electrostatic fluid distribution, the equation of continuity for electrons can be written as –

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

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 ∇=ik. Thus linearizing the above equation one obtain-

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

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

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

The equation of motion for electron is –

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

Here γ_{en} is the binary 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.

1.2. Calculation of Distribution

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

$\frac{e}{m}[ik\varphi - i\omega A] - iC_e^2 k\frac{n_e}{n_{eo}} - \vartheta_{en}\frac{\omega}{k}\frac{n_e}{n_{eo}} = 0$ ……….(4)

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

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

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

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

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

$n_e = n_{eo}\, i\frac{\frac{e}{m_e}\left(\frac{1}{\vartheta_{en}}\right)(\varphi - \frac{\omega}{k}A)k^2}{\omega + i(C_e^2 k^2/\vartheta_{en})}$ ………(5)

Similarly for ion,

$n_{i=}n_{eo}\, i\frac{\frac{e}{m}\left(\frac{1}{\vartheta_{in}}\right)(\varphi - \frac{\omega}{k}A)k^2}{\omega + i(C_i^2 k^2/\vartheta_{in})}$ …………(6)

Here ϑ_{in} is the binary 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.

2. 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.

3. References

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