Electromagnetic waves and Fields at an advance level:-

Electromagnetic radiation, is a form of energy emitted by moving charged particles. As it travel through space it behaves like a wave, and has an oscillating electric field component and an oscillating magnetic field. These waves oscillate perpendicular to one another and also in phase.

The creation of all electromagnetic waves begin with a charged particle. The charged particle creates an electric field. When it accelerates as part of its oscillatory motion, it creates ripples, or oscillations in its electric field and also produces a magnetic field. Once in motion, the electric and magnetic fields created by a charged particle are self-perpetuating, time-dependent changes in one field (electric or magnetic) produces the other.

Electromagnetic waves have energy and momentum, both are associated with their wavelength and frequency.

$$E = hf = \frac{hc}{\lambda}$$

$$P = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

Jeans instability causes the collapse of interstellar gas clouds and subsequent star formation. This instibility was first demonstrated by Jeans in 1902, so it is called Jeans instability. It occours when internal gas pressure is not strong enough to prevent gravitational collapse of a region filled with gas.

Dispersion Relation of Electromagnetic Wav

In recent years, a great deal of attention has been paid to the phenomena of collective processes in dusty plasma because dusty plasma are known to be rather common in space ranging from interplanetory, interstellar to intergalactic media and such a plasma can play a role in the formation of stars, galaxies, and planetory system,

Jeans mass is the critical mass where both forces 1) The outward gas pressure (radiation Pressure)

2) The inward gravitational force

are in equilibrium with each other.

Standard dispersion relation of Photons in the region (without plasma) is given as

$$\omega = cK$$

Behaviour of Photons in Plasma is radically different from the behaviour in vaccum. As plasma particles perform oscillatory motion in the field of electromagnetic waves, the radiation field is affected. The oscillation of electrons in an isotropic homogeneous plasma causes the index of refraction to depend on the radiation frequency, which is non-close to unity. in a dense plasma, The dispersion relation is given by

$$\omega = \left(\omega_{pe}^2 + c^2 K^2\right)^2$$

If $K = 0$ (no wave propogation)

then $$\boxed{\omega = \omega_{pe}}$$

where ω_{pe} the Langmuir frequency is

$$\boxed{\omega_{pe} = \left(\frac{4\pi n_0 e^2}{m_e}\right)^{1/2}}$$

Now based on the following conditions, the magnatohydrodynamic (MHD) equation will be derived for dusty plasma under the effect of thermal radiation and gravitating field

1) the plasma is quasi neutral
2) the temperature of dust-grain T_d is less than the temperatures of electrons and ions i.e $T_d < T_{e,i}$
3) So neglecting the gas dynamics and

Radiation Pressures of dust grains.

Equation of Motion :-

In general the equation of motion is given as

$$m_\alpha n_\alpha \frac{d v_{\alpha j}}{dt} = e_\alpha n_\alpha \left[\vec{E} + \frac{1}{c}(v_\alpha \times \vec{B})\right] - \nabla P_\alpha^t - R_\alpha - m_\alpha n_\alpha \vec{\nabla}\psi \quad \text{—— (A)}$$

where α = species

j = component

P_α^t = Total pressure

$m_\alpha n_\alpha = \rho_\alpha$ (number density).

Continuity Equation :-

$$\frac{\partial n_\alpha}{\partial t} + \nabla \cdot (n_\alpha v_\alpha) = 0 \quad \text{—— (B)}$$

Now writing set of fluid equations for each specie. Equation of motion for inertial less electrons and ions respectively.

$$m_e n_e \frac{d v_e}{dt} = -e n_e \left[\vec{E} + \frac{1}{c}(v_e \times \vec{B})\right] - \nabla(P_{ge} + P_{re})$$

where $\nabla P_e^t = \nabla(P_{ge} + P_{re})$

(gravitational Pressure + Radiation Pressure)

For ions

$$m_i n_i \frac{dV_i}{dt} = e n_i \left[\vec{E} + \frac{1}{c}(V_i \times \vec{B})\right] - \nabla(P_{gi} + P_{ri})$$

As mass of electron and mass of ion is much less then the mass of dusty particles, so

$$m_i \approx m_e \approx 0$$

∴ So equation of motion for electrons;

$$0 = -e n_e \vec{E} - \frac{1}{c}\left[e n_e (V_e \times \vec{B})\right] - \nabla(P_{ge} + P_{re}) \quad \text{--- (1)}$$

For ions;

$$0 = Z_i e n_i \vec{E} + \frac{1}{c}\left[Z_i e n_i (V_i \times \vec{B})\right] - \nabla(P_{gi} + P_{ri}) \quad \text{--- (2)}$$

For dust;

$$m_d n_d \frac{dV_d}{dt} = -Z_d e n_d \vec{E} - \frac{1}{c}\left[Z_d e n_d (V_d \times \vec{B})\right] - \rho_d \nabla \psi \quad \text{--- (3)}$$

∵ As $T_d \ll T_e$ & T_i so pressure is neglected in the case of dust. i.e $P_{gd} \approx P_{rd} \approx 0$

Now adding eqs (1), (2) and (3) we get one fluid MHD eqs.

$$m_d n_d \frac{dV_d}{dt} = -e\left[n_e \vec{E} - Z_i n_i \vec{E} + Z_d n_d \vec{E}\right] + \frac{e}{c}\left[-n_e V_e + Z_i n_i V_i - Z_d V_d V_d\right] \times \vec{B} - \nabla(P_{ge} + P_{re} + P_{gi} + P_{ri}) - \rho_d \nabla \psi$$