Elementary Concepts of Plasma

Course: MPHYEC-01I Plasma Physics (M.Sc. IV Sem)

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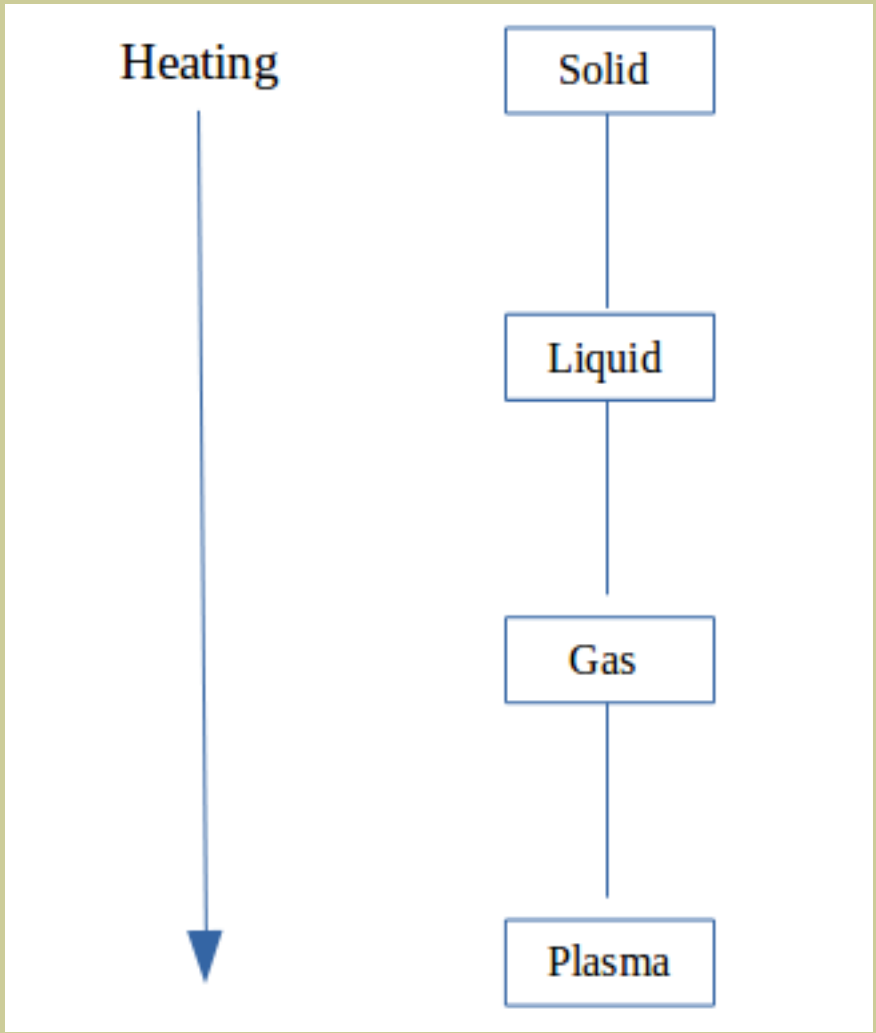
Lecture 1: Unit-I

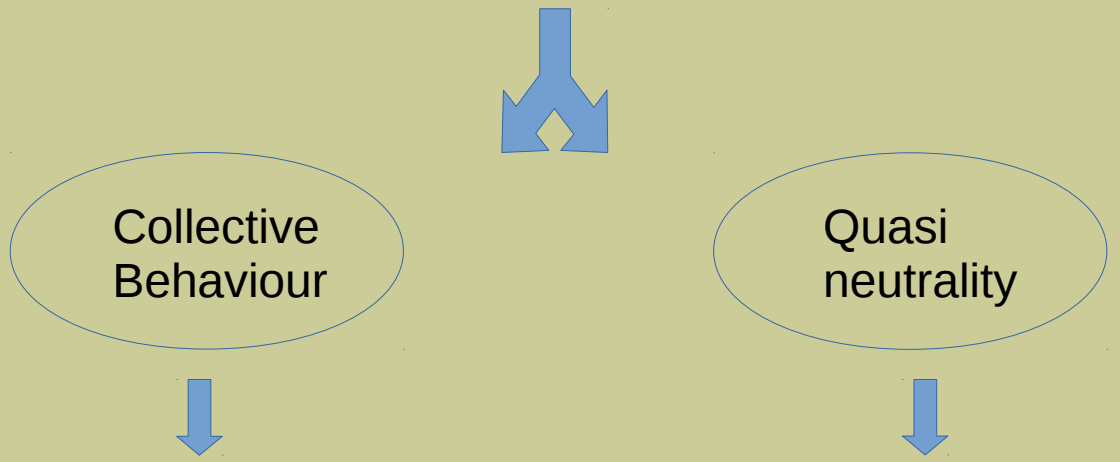
What is plasma?

- **Plasma can be considered as an ionized gas.**
- **Also called “fourth state of matter”.**
- **How to generate plasma?**



Formal Definition of Plasma

"Plasma is a collection of charged and neutral particles which exihibit the collective behaviour and obey the condition of quasi-neutrality."



Charged particles can communicate to the other charged partcles situated at large distance through long-range EM forces. Due to this connectivity, the plasma responds collectely to any perturabation.

Number density of electrons (n_e)

Is approximately equal to number density of ions (n_i).

Examples of Plasma Systems

It is believed that around 99% visible matter in the universe is in plasma state

Plasma Temperature

Concept of temperature: A gas in thermal equilibrium, the most probable distribuation of velocities of the particles is given by the Maxwellian distributation: $f(v)= A \exp(-mv^2/2kT)$
where $A=n(m/2\pi kT)^{1/2}$ with n representing the number density. Then the averaged kinetic energy of particles is calculated as:

$$E_{av}=\left(\int_{\infty}^{\infty} (mv^2/2) f(v) dv \right) / \int_{\infty}^{\infty} f(v) dv$$
$$=1/2\ kT$$

Averaged kinetic energy is 1/2kT for 1D and 3/2kT for 3D.
Therefore, temperture is nothing but the averaged kinetic energy of the particles in equilibrium.

Plasma Temperature (Contd.)

- Collisions of the particles which thermalize the system and take the system to equilibrium state in which particles follow the Maxwellian distribution and the temperature can be defined in terms of averaged kinetic energy of the particles.

- Different types of collisions are possible in plasma as there can be three different types of species: electrons, ions, and neutral.

- Each species can be in its own thermal equilibrium and there can be different temperatures in plasma; electron temperature T_e, ion temperature T_i, neutral temperature T_n.

- If we wait for a long enough time, the inter-species collisions equilibrate different temperatures i.e., Te =Ti =Tn =T.

Reference books for the course

1. Fundaments of Plasma Physics by *J. A. Bittencourt*
2. Introduction to Plasma Physics and Controlled Fusion by *Francis F. Chen*
3. Introduction to Plasma Physics by *Robert J Goldston and Paul H Rutherford*
4. The Physics of Fluids and Plasmas: An Introduction for Astrophysicists *by Arnab Rai Choudhuri*

Thanks !