

Plasma PhysicsBasic Properties & OccurrenceDefinition of Plasma

States of matter — solid, liquid & gas

Solid, liquid states → Organized by the action of short range intercrystalline or cohesive forces.

Fourth state of matter → plasma

Plasma → Ionized gas with a sufficiently high density so that there exists force of interaction → coulomb electrostatic force

→ Mixture of free electrons, positive ions and neutral atoms (or molecules)

~~Any ionized~~

most wide spread state of matter in the universe

Ionosphere → Plasma envelope surrounding earth's atmosphere

Sun, stars → huge of hot plasmas

99% of the matter in the universe \rightarrow plasma state

Ionized gas \rightarrow atoms dissociated into positive ions & negative electrons.

Stellar interiors, and atmospheres, gaseous nebulae, much of interstellar ~~plasmas~~ hydrogen



Plasmas

Outside earth's atmosphere: - Plasma comprising the Van Allen radiation belts and the solar wind.

Everyday lives encounters: - ionized plasma

- Example:
- Flash of lightning bolt
 - Soft glow of Aurora Borealis
 - Conducting gas inside fluorescent tube or neon sign
 - Slight amount of ionization in rocket exhaust

We live in I.F. universe \rightarrow plasma don't occur naturally

Reason!

Saha Equation

$$\frac{n_i}{n_n} \approx 2.4 \times 10^{21} \frac{T^{3/2}}{n_e} e^{-U_i/KT} \quad (1)$$

n_i & $n_n \rightarrow$ density of ionized atoms and neutral atoms

$T \rightarrow$ gas Temp in $^{\circ}K$. (number per m^3)

$k \rightarrow$ Boltzman constant

$U_i \rightarrow$ ionization energy of the gas

for ordinary air at room temperature

we may take

$n_n \approx 3 \times 10^{25} m^{-3}$, $T \approx 300^{\circ}K$, $U_i = 14.5 eV$
(for N_2)

$1 eV = 1.6 \times 10^{-19} J$

The fractional ionization $\frac{n_i}{n_i + n_n} \approx \frac{n_i}{n_n}$

$\frac{n_i}{n_n} \approx 10^{-12}$

As $T \rightarrow$ raised, degree of ionization

remains low until U_i is only a few times kT

Then $\frac{n_i}{n_n}$ rises abruptly \rightarrow gas is in plasma state

Further increase in T

$n_n < n_i \rightarrow$ Plasma fully ionized

Plasma exists in astronomical bodies with temperature of millions of degrees

\hookrightarrow but not on the earth.

life could not easily exist with a plasma
Natural occurrence of plasmas → at high temperatures

↓
Fourth state of matter

Any ionized gas → not plasma X

↳ some degree of ionization is present in any gas.

A plasma → is a quasineutral gas of charged and neutral particles which exhibits collective behaviour

Quasineutral → ? discuss later

Collective behaviour →

↓
Motions that depend not only on local conditions but on the state of the plasma in a remote regions as well.

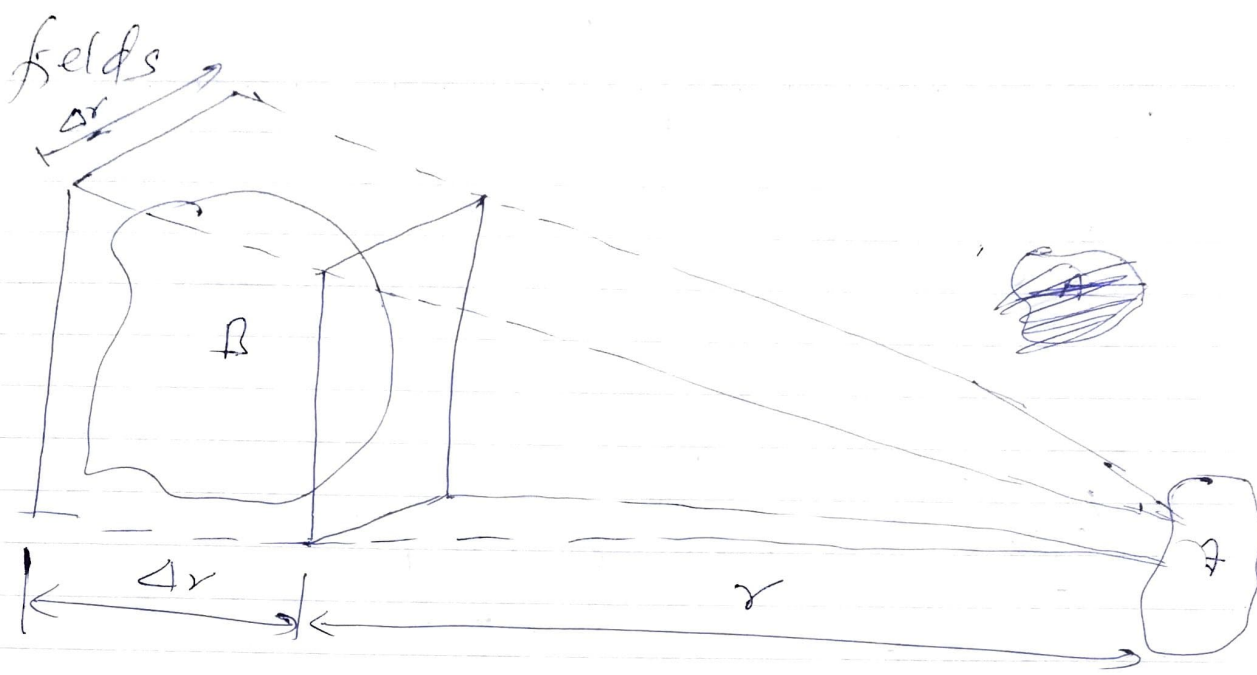
→ Plasma does not tend to conform to external influence → it often behaves as if it had a mind of its own.

Molecules of ordinary air

No net electromagnetic force

Totally different from → plasma behaviour

Charged particles in plasma give rise to electric fields \rightarrow hence magnetic



long-range electrostatic forces in plasma
 Elements of plasma exert a force on one another even at large distances \rightarrow long-range Coulomb force

Astrophysical Plasmas

Solar wind, Galaxy cluster
 Galactic center

stream of energized, charged particles, electrons & protons

flowing inward from Sun through solar system at speed as high as 900 km/s and at $T \approx 1$ million degree Celsius

Astrophysical plasmas → that occur in space ¹¹

↓ includes the plasma that makes up stars. The sun is constantly emitting a plasma known as the solar wind, which can affect satellites in orbit around the earth and create aurora. Plasma also found in interstellar space.

Astronomical objects → consists of matter that is ionized and has large enough density of charges to produce collective behaviour.

These objects are composed of matter in plasma state.

Examples :- Atmospheres of stars, including the sun, the interstellar medium, gas between the stars, accretion disks around black holes, radio galaxies etc.

Debye Shielding

Fundamental characteristic of the behaviour of a plasma is its ability to shield out electric potentials that are applied to it.