Introduction to plasma state in nature and in the laboratory

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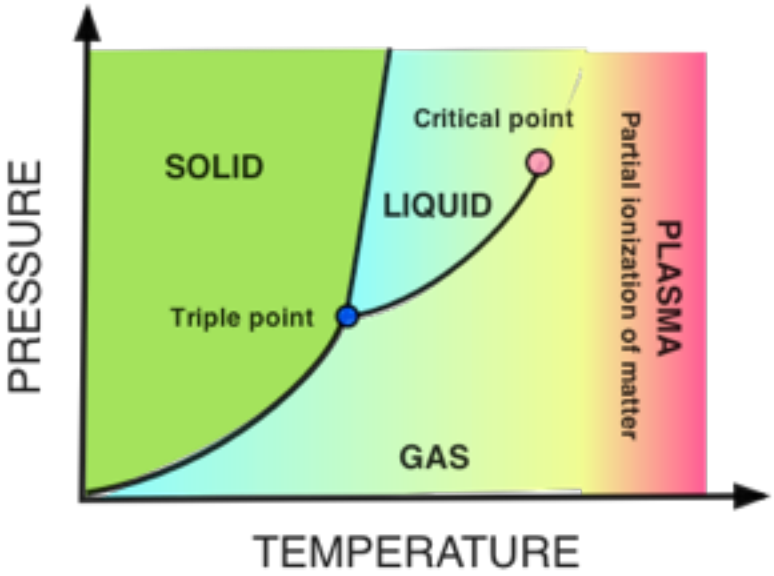
Equilibrium state of condensed matter

The classical *equilibrium states* of matter in nature are electrically neutral and plasmas are usually associated to high temperature states of condensed matter.



The plasma state is a *non equilibrium state of condensed matter* and the transition from neutral gas to plasma is gradual, no phase transition from a neutral gas to a plasma

Plasma production:

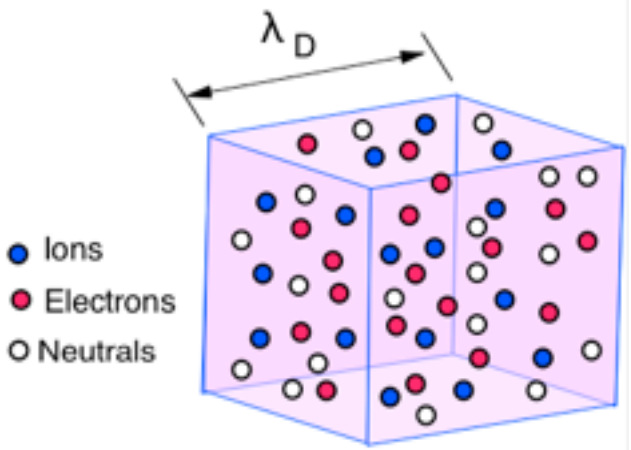
- Neutral gas heating
- Ionizing radiation
- Collisional ionization

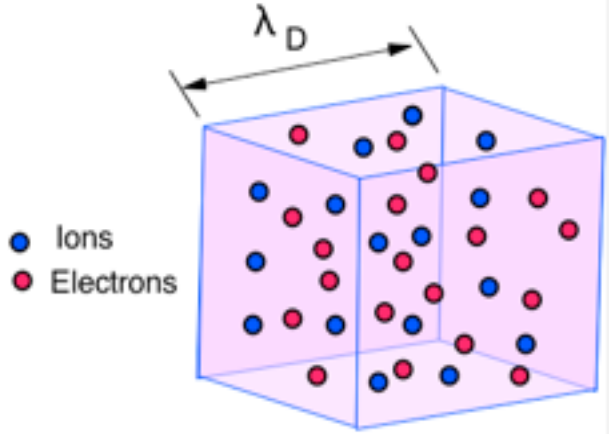
Plasma state of condensed matter is, …

- The *classical plasmas* are mixtures of electrons, ions and neutral atoms, resulting from the partial ionization of a neutral gas. The *dusty plasmas* also contain charged solid grains.
- They are roughly characterized by the densities n_e n_i of charged particles, neutral gas atoms n_a and the equilibrium temperature T
- The plasma is said *fully ionized* when the density of neutral atoms is n_a negligible and *partially ionized* otherwise.

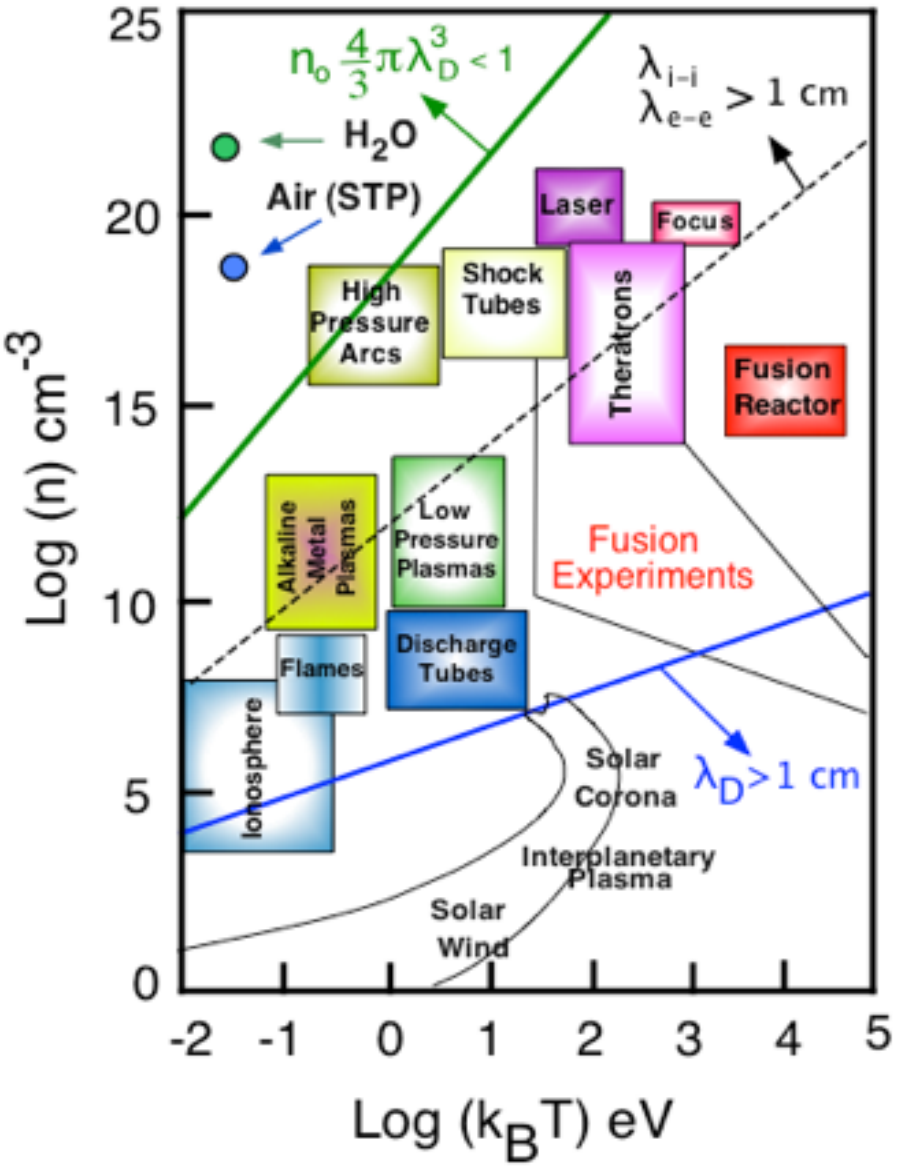
The electric field, …

$$\nabla \cdot \boldsymbol{E} = \frac{e}{\epsilon_o}\left(Z\, n_i - n_e\right) \qquad \mathbf{E} \simeq 0 \qquad L \simeq \lambda_D$$
$$n_e \simeq n_i$$





Plasmas in nature and in the laboratory



Plasmas are roughly classified according to the densities of charged particles and their average kinetic energies

Water at room temperature:
$k_BT \approx 0{,}025$ eV, $n \approx 10^{22}$ cm^{-3}

Fusion reactor: $k_BT \approx 10^4$ eV, $n \approx 10^{15}$ cm^{-3}

Laser plasmas: $k_BT \approx 10^2$ eV, $n \approx 10^{20}$ cm^{-3}

Glow discharge: $k_BT \approx 1\text{-}3$ eV, $n \approx 10^8$ cm^{-3}

Ionosphere: $k_BT \approx 0{,}05$ eV, $n \approx 10^6$ cm^{-3}