Applications of Plasma Science and Technology

How Come Plasma So Potently Useful For So Many Applications ?

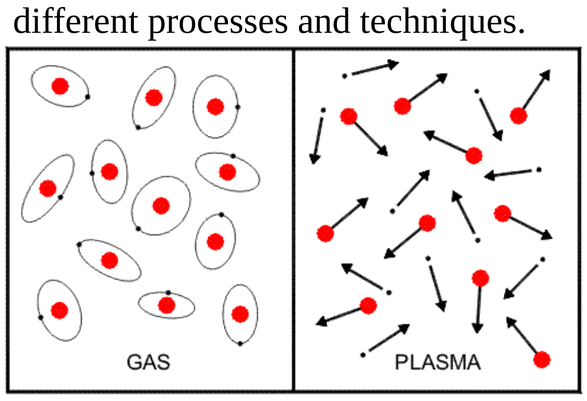
Institute for Plasma Research, Gandhinagar, 382 428, Gujarat (India)
www.ipr.res.in

The Sun -the origin of energy that sustain life on earth for billions of years-, the Lightening thunderbolts that strike from the sky with such tremendous power are all **demonstrations of what plasma can do** !

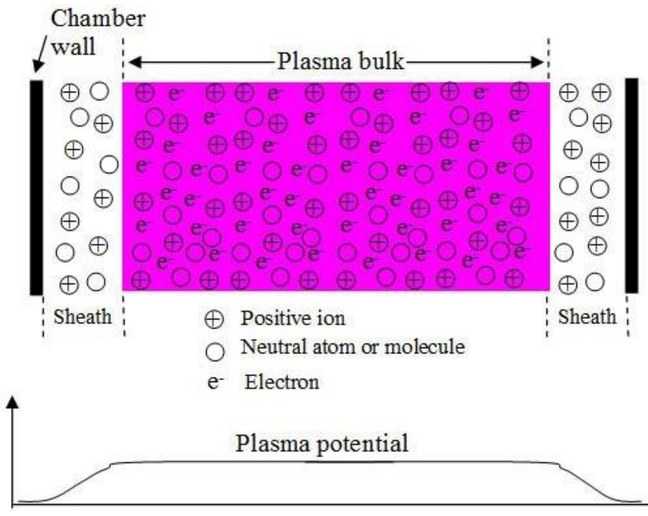
Its astonishing to see how even inert gases, which otherwise can only do only mechanical effects, spring to a totally new life and become powerfully versatile in characteristics and behaviour the moment it get ionized and become plasma !

This highest energised state of matter, consisting of free electrons and ions and so of high electrical conductivity and responsive to the electric and magnetic fields, has become a medium of tremendous potential for the future of science and technology and so big hope for human life and well being.

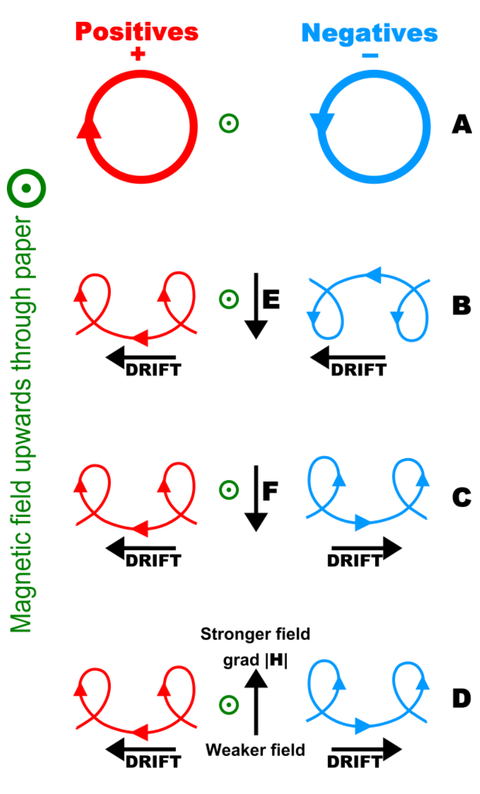
Plasma formed as a result of ionization of gas are clouds of freely moving charged particles which can **interpenetrate, interact and influence and act on in long ranges.** Their actions itself generate both generate electromagnetic fields which , in turn, lead to further distinct behaviours making it poetentail for different processes and techniques.



Plasma is a **mixture of force field and matter** and so can act numerous ways.



Similar charged particles in plasma group together to form electrostatic sheath around a charged object that is immersed in it. The strength of the electric field around such a ball **completely shielded with in a distance called Debye length**. Higher the density of the charged particles the shorter this length and higher the plasma temperature and its stability. This property and its control give rise to many major applications for plasma



Charged particle motions in homogeneous magnetic field.

(A) No disturbing force

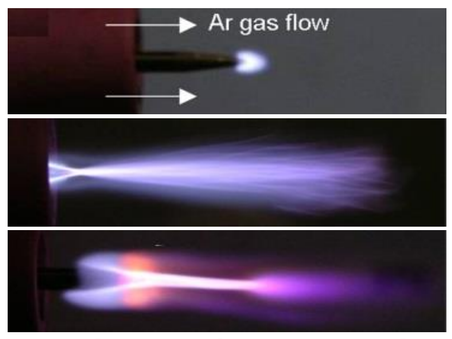
(B) With an electric field E

(C) With an independent force, F like gravity

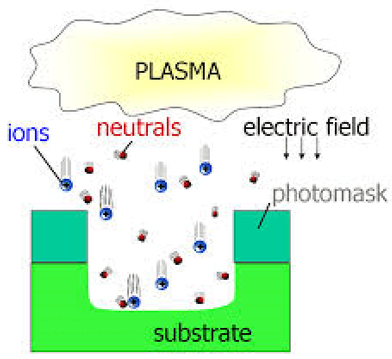
(D) In an inhomogeneous magnetic field, grad H

The plasma particles **could be tuned,steered and accelerated.** As the electromagnetic forces act at very large distances, plasma also exhibits the unique collective behaviour just like fluid.

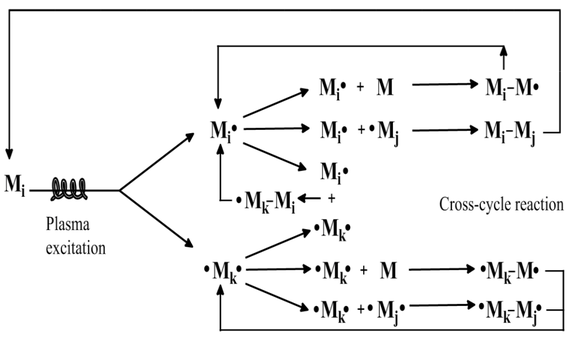
The non equilibrium plasma is characterised by charged species having much higher kinetic energy than neutrals . The energy supplied externally was efficiently transported to targets by these much faster than they can transfer it to neutrals present in the plasma. This has significant use in **thermal disassociation** because of high temperature and ionizing capacities.



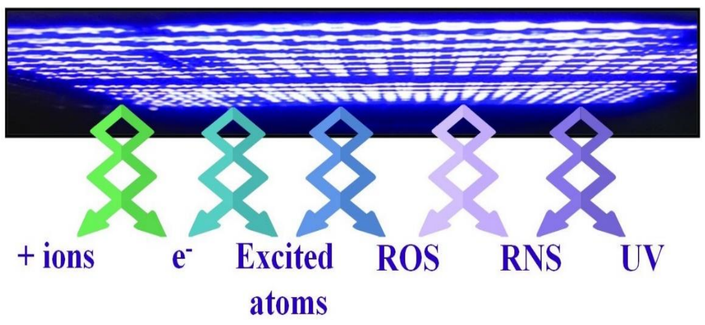
The fast response of plasma, with its possible multiple ion species and neutral particles, to electric and magnetic field gives rise to great diversity of waves and oscillations. These waves that propagate in plasma have large number of wave modes in HF and RF



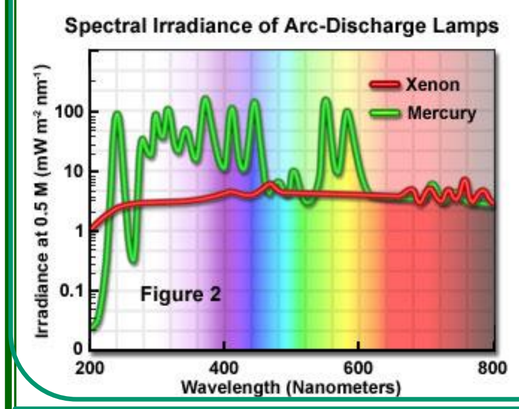
High-speed pulsed glow discharge plasma of appropriately selected gas mixture can have ions as well as neutral particle as atoms and radicals which generate volatile products at room temperature through the chemical reactions that happens at the surface of the material immersed in the plasma .This results in **embedding the elements** and atoms on the surface or just below it resulting in **etching or modifying the physical properties** of the sample.



Gaseous and liquid monomers **could be activated and fragmented by suitable plasma discharge** to initiate polymerization and the products formed are highly cross linked and branched that get very well attached to desired solid surfaces.

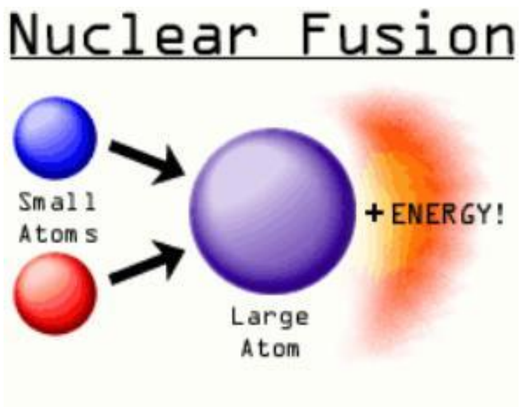


The plasma arc discharges emits almost the **entire visible as well as UV wavelengths** comparable only to normal sun light spectrum making it ideal light sources for the future.



The UV and reactive chemical products emanating from cold plasma ionization process results in reactive gases which can **inactivate microbes** in fruits, vegetables, meats and poultry and in **modifying food material for desired effects** maintaining the nutritional and textural properties

If positively charged nuclei come close enough to overcome the repulsive electric force between them the **strong force that binds the protons and neutrons together takes over and pulls the nuclei closer making the fusion** to happen as it is in the sun where enormous gravitational pulls help doing this same. Very high temperature tightly confined sufficiently long plasma can makes this happen on earth and become an endless source of energy.



In short we can say that particles in plasma can act in unison behaving as a collective group of animals under our command and direction .

The study of plasma physics basically has that aim and the opportunities that it can generate for human welfare are enormous !

Illustrations owed to Internet websites and readily available on image search with related keywords