SRI AKILANDESWARI WOMEN'S COLLEGE WANDIWASH

HISTORY & APPLICATION OF PLASMA PHYSICS

CLASS : II PG PHYSICS

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OUTLINE

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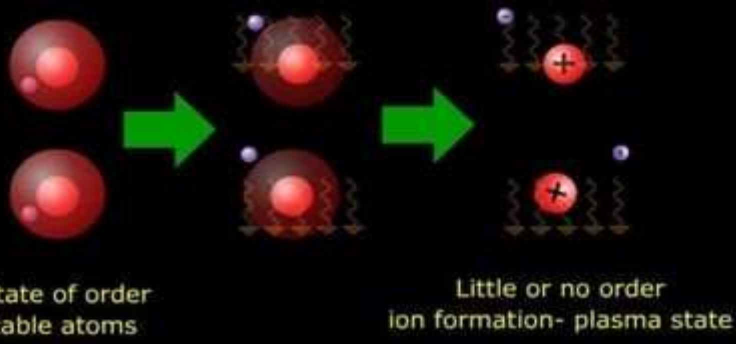
- HISTORY
- PLASMA FOURTH STATE OF MATTER
- COMPARISION OF PLASMA AND GAS PHASE
- WHERE WE FIND PLASMA
- WHY WE NEED PLASMA
- APPLICATIONS
- FUSION ENERGY
- FUTURE OF PLASMA PHYSICS

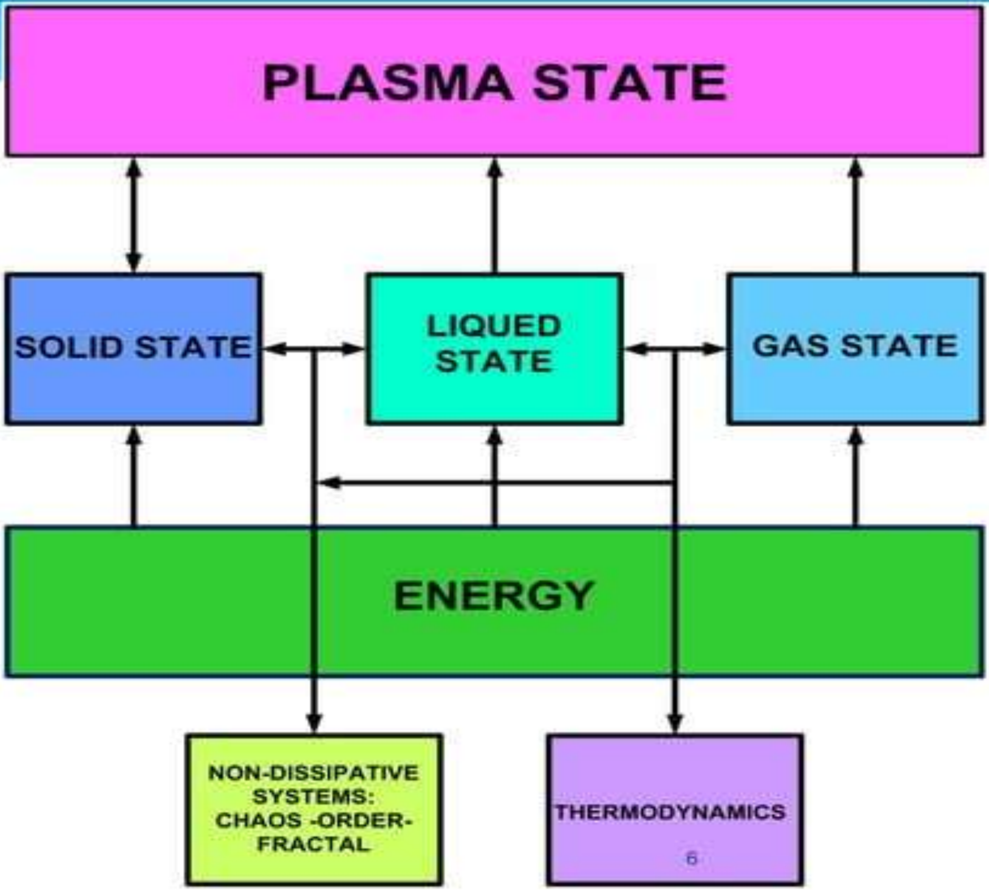
HISTORY OF PLASMA

- Plasma was first identified in a Crookes tube described by Sir William Crookes in 1879
- The term "plasma" was coined by Irving Langmuir in 1928

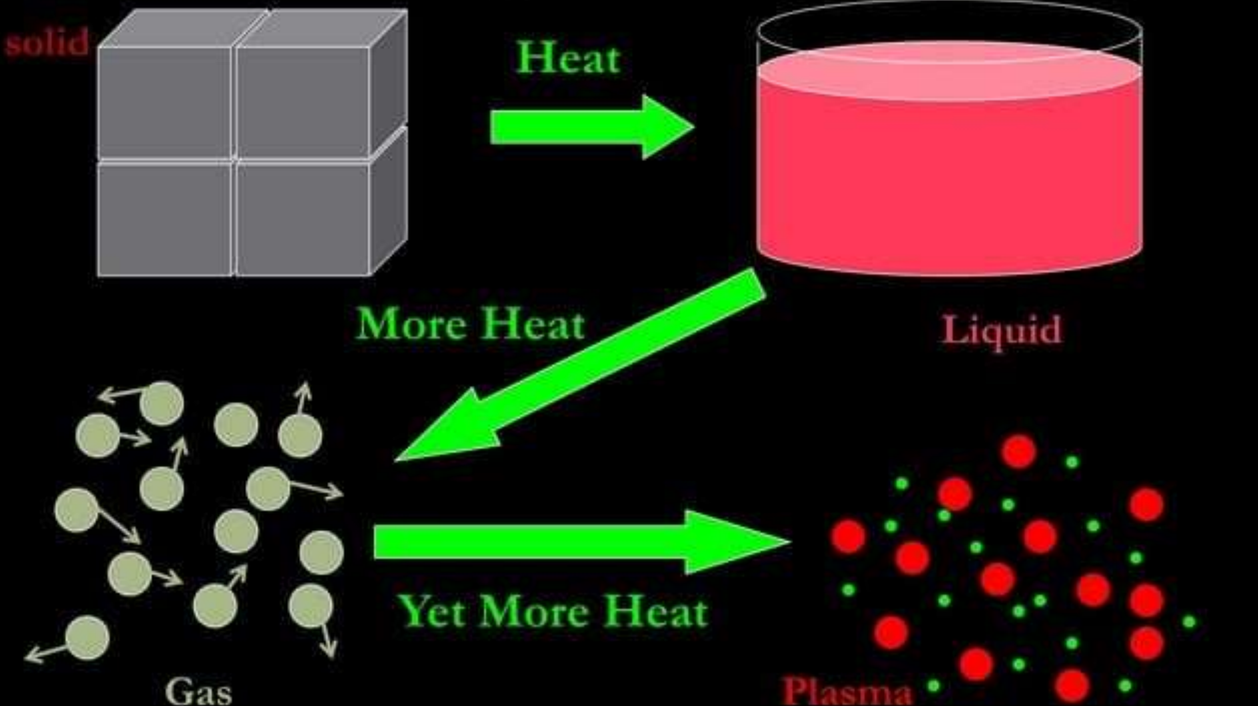


INTRODUCTION

- Plasma means moldable Substance
- Its is the fourth state of matter
- The material has become so hot that electrons are no longer bound to individual nuclei. Thus a plasma is electrically conducting, and can exhibit collective dynamics.
- More than 99% mass of universe is in Plasma state


PLASMA STATE
SOLID STATE
LIQUED STATE
GAS STATE
ENERGY
NON-DISSIPATIVE SYSTEMS: CHAOS -ORDER- FRACTAL
THERMODYNAMICS
6

PLASMA--4TH STATE OF MATTER



Main parameters of plasma

1. Density Ne – number of electrons in volume, 1/cm³.
2. Temperature T, [eV]. 1 eV = 11606 K ~ 10^4K.

$$e \cdot U = \frac{mv^2}{2} \Rightarrow \frac{3}{2} \cdot kT$$

eU[J] ⟶ eU[eV] kT[J] ⟶ T[eV]

3. Langmuir frequency- plasma frequency:

$$\omega_p = \sqrt{\frac{4\pi n e^2}{m}}$$

$$\omega_p\ [\text{с}^{-1}] = 5{,}6 \cdot 10^4 \cdot \sqrt{n\ [\text{см}^{-3}]}$$

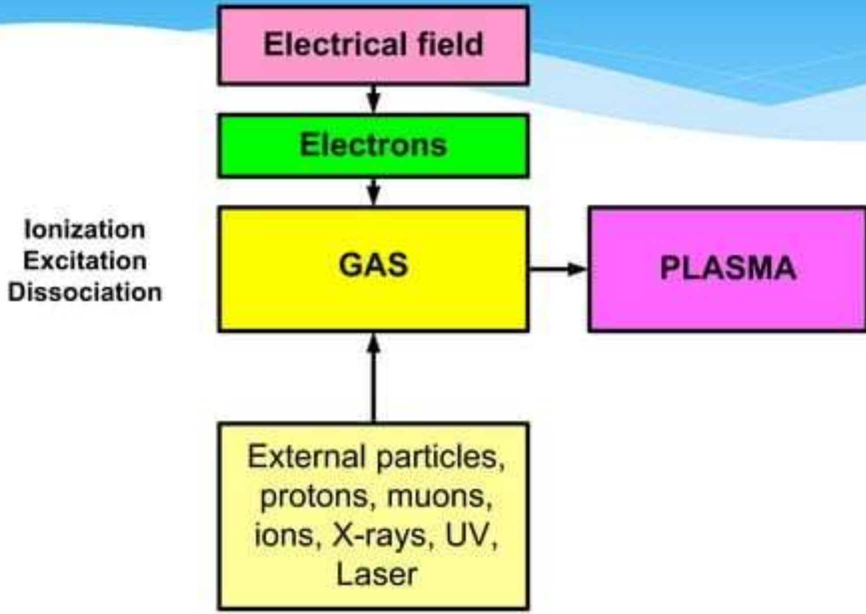
COMPARISON OF PLASMA AND GAS PHASES

PROPERTIES	GAS	PLASMA
Electrical conductivi-ty	**Very low**: Air is an excellent insulator until it breaks down into plasma at electric field strengths above 30 kilovolts per centimeter	**Usually very high**: For many purposes, the conductivity of a plasma may be treated as infinite
Independen-tly acting species	**One**: All gas particles behave in a similar way, influenced by gravity and by collisions with one another.	**Two or three**: Electrons, ions, protons and neutrons can be distinguished by the sign and value of theircharge
Velocity distribution	Maxwellian: Collisions usually lead to a Maxwellian velocity distribution of all gas particles	**Non-Maxwellian**: Collisional interactions are often weak in hot plasmas and external forcing can drive the plasma far from local equilibrium and lead to a significant population of unusually fast particles.
Interactions	**Binary**: Two-particle collisions are the rule, three-body collisions extremely rare.	**Collective:**the particles can interact at long ranges through the electric and magnetic forces.

Types of Plasma

1. Ionized gas. More understanding.
2. Ionized solid state (Example: ionized semiconductors (Fast ionized dinistors)).
3. Ionized liquid (Example: breakdown of water or oil).
4. Dust plasma.
5. Cluster plasma (Example: evaporated plasma in electron source).

Gas plasma


Electrical field
Electrons
Ionization
Excitation
Dissociation
GAS
PLASMA
External particles, protons, muons, ions, X-rays, UV, Laser

WHERE DO WE FIND PLASMAS?

- Examples of plasmas on Earth:
  - Lightning
  - Neon and Fluorescent Lights
  - Laboratory Experiments
- Examples of astrophysical plasmas:
  - The sun and the solar wind
  - Stars, interstellar medium

ON EARTH

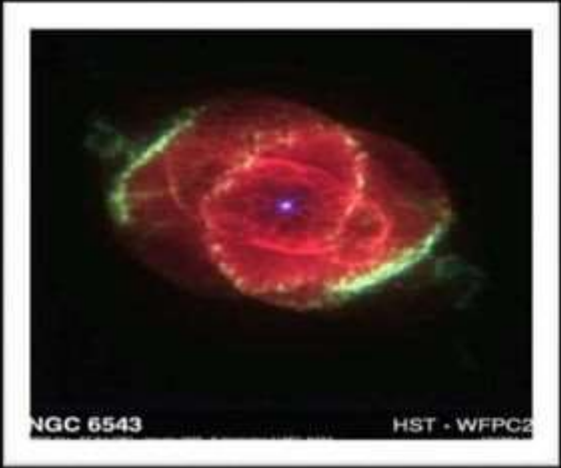
Laboratory Experiments

Lightning

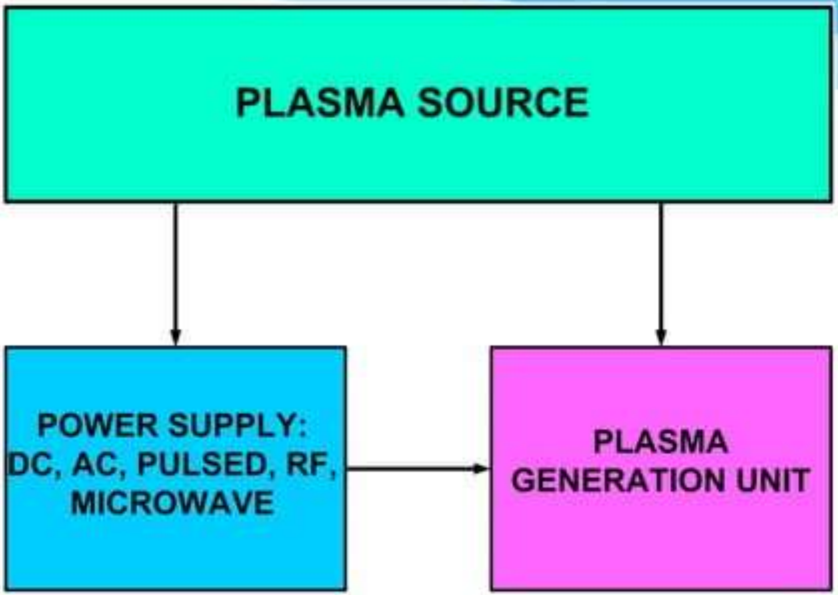
ASTROPHYSICAL PLASMAS

THE SUN

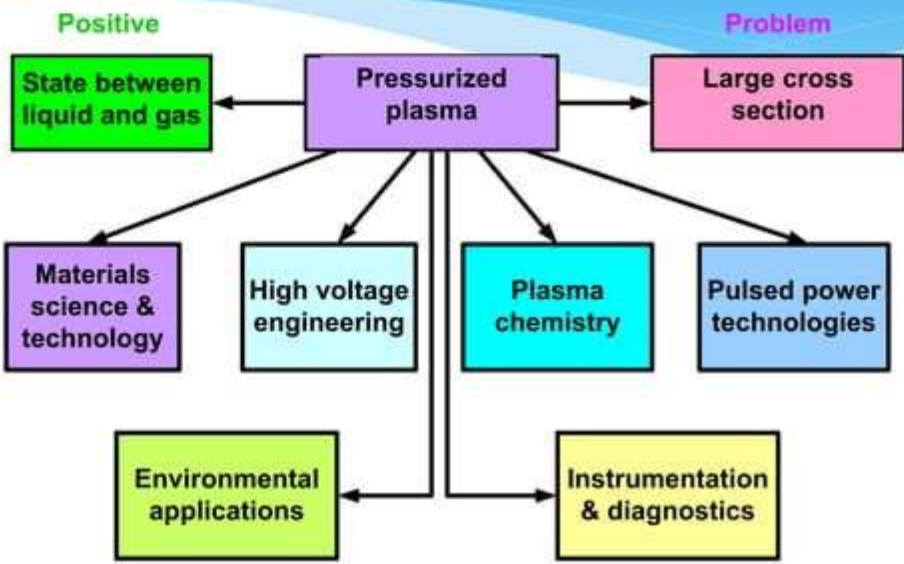
Catseye Nebula



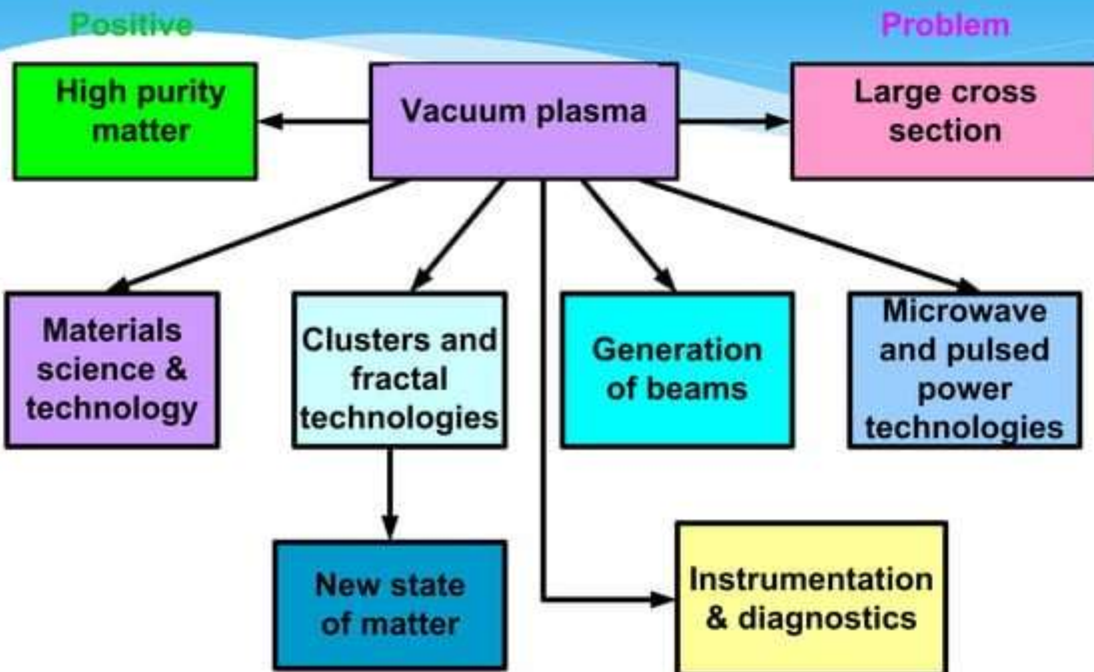
General structure of active plasma source



Atmospheric plasma



Vacuum plasma



WHY WE ARE INTERESTED IN PLASMA??

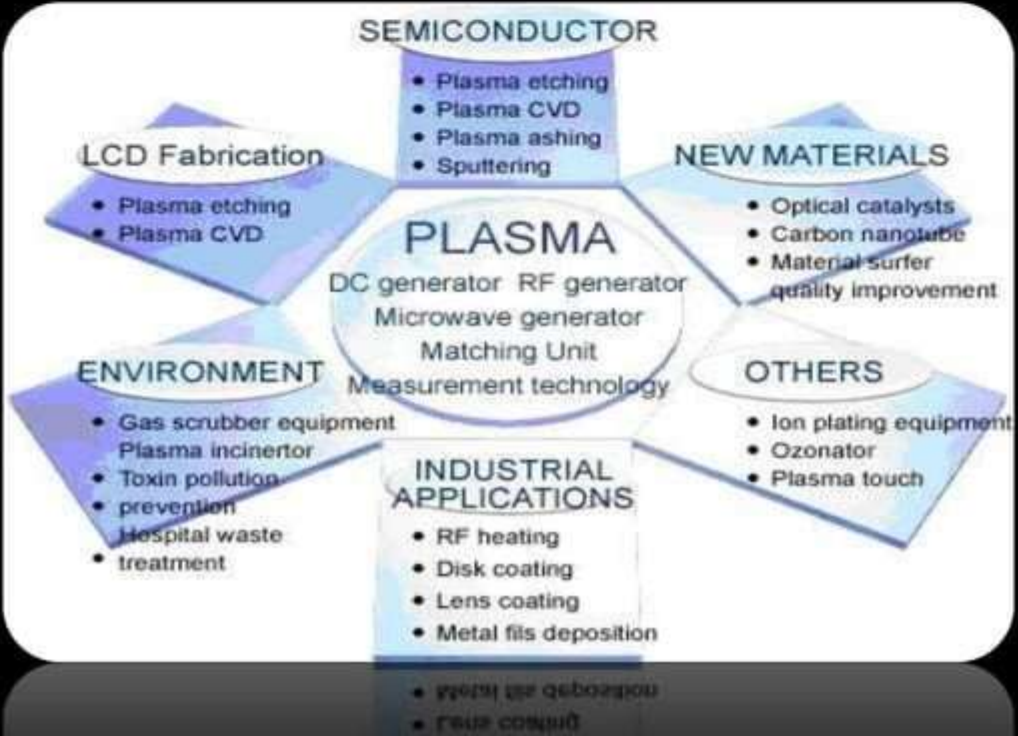
- Fusion Energy

  Potential source of safe, abundant energy.
- Astrophysics

  Understanding plasmas helps us understand stars and stellar evolution.
- Upper atmospheric dynamics

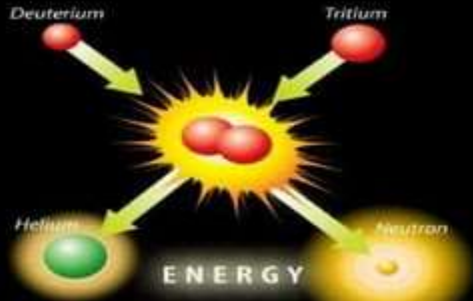
  The upper atmosphere is a plasma.

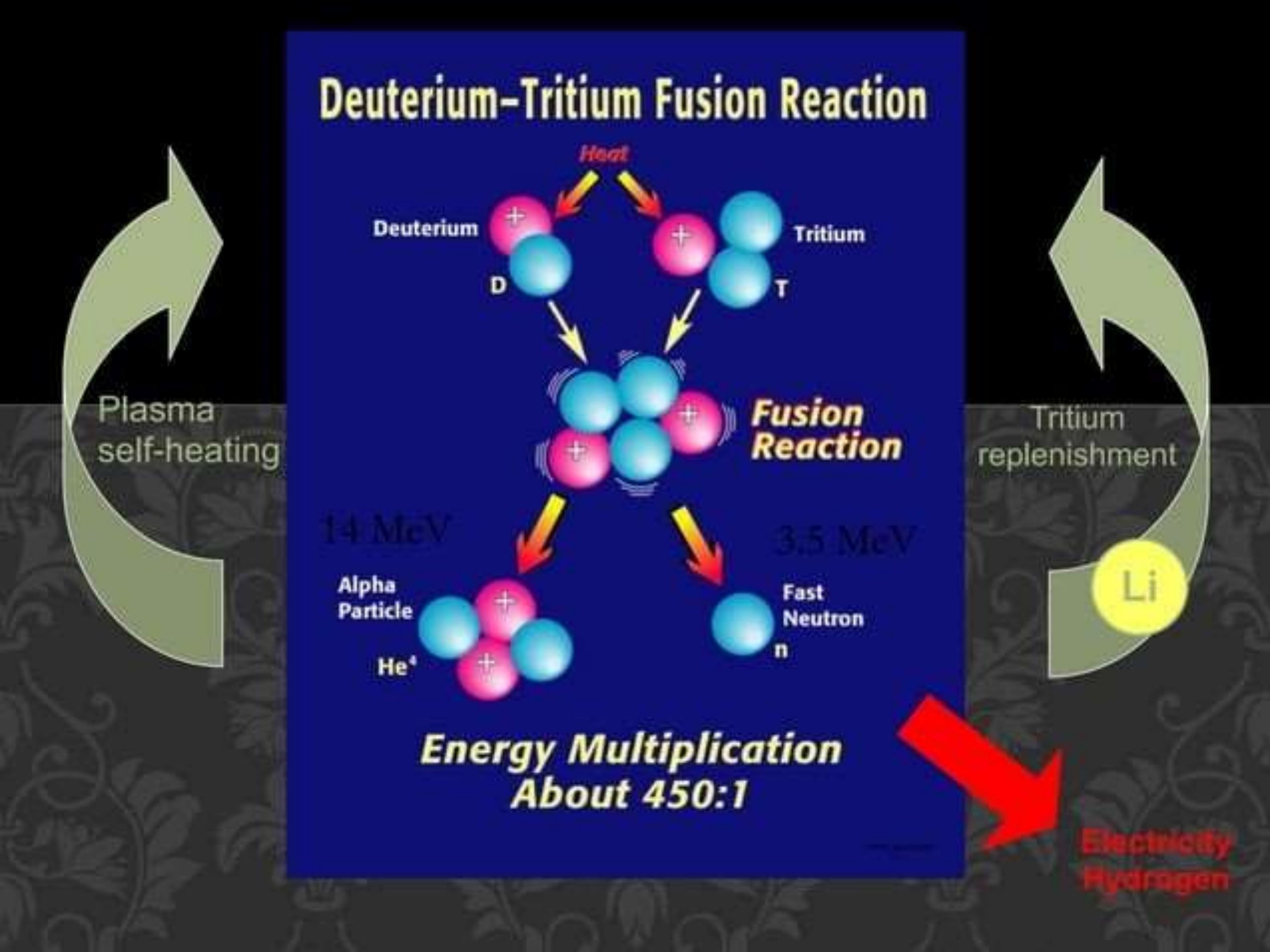
APPLICATIONS



PLASMA IN FUSION ENERGY

- Much of plasma physics research has been motivated by the goal of controlled fusion energy.
- Fusion energy is a form of nuclear energy which is emitted when two light nuclei combine to form a single more stable nuclei.
- The sun and stars derive their energy from fusion.

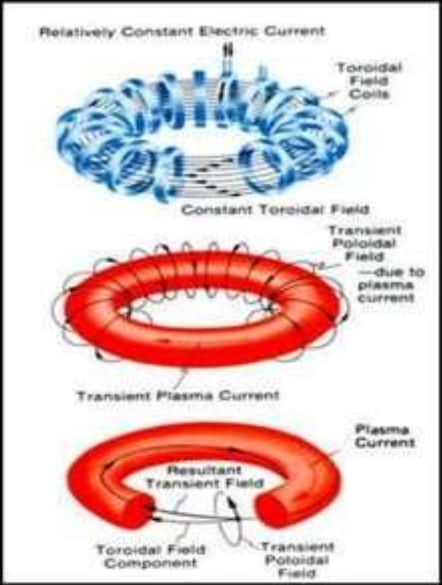




Deuterium–Tritium Fusion Reaction
Heat
Deuterium
D
Tritium
T
Fusion Reaction
14 MeV
3.5 MeV
Alpha Particle
He4
Fast Neutron
n
Energy Multiplication About 450:1
Plasma self-heating
Tritium replenishment
Li
Electricity
Hydrogen

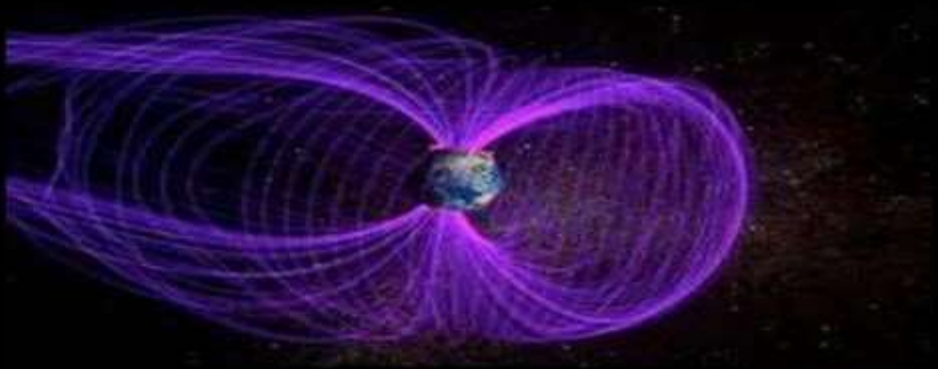
TOKAMAK

- It uses a powerful magnetic field to confine plasma in the shape of a torus.
- It is magnetic confinement device developed to contain the hot plasma needed for producing controlled thermonuclear fusion power



FUTURE OF PLASMA PHYSICS

- NEW AREA FOR RESEARCH AND DEVELOPMENT
- GREAT FEATURES
- WIDE RANGE OF APPLICATION
- POWERFUL ENERGY SOURCE



THANKS...