EE403/503 - Introduction to Plasma Processing

Introduction & Plasma Applications

January 16, 2013

EE403/503 - Introduction to Plasma Processing

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Office Hours: Tuesdays 2:00 p.m. - 3:00 p.m.
or by appointment

1- What is Plasma

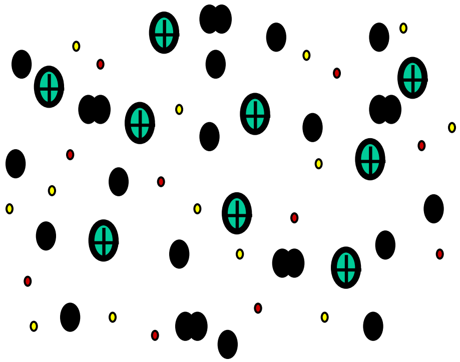
2- Plasma Applications

3- EE 403/503 Website

What is Plasma ?

Mixture of freely moving

- Neutrals (atoms and molecules)
- Ions
- Electrons
- Photons



Plasmas are Electrically Conducting
Overall Electrically Neutral

4th State of Matter

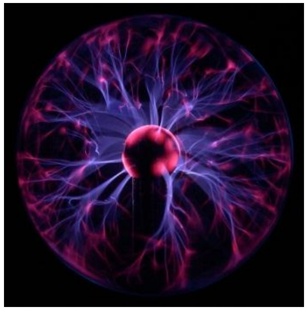
Solid, Liquid, Gas and Plasma

More Than 99.99% of the universe is in the plasma State

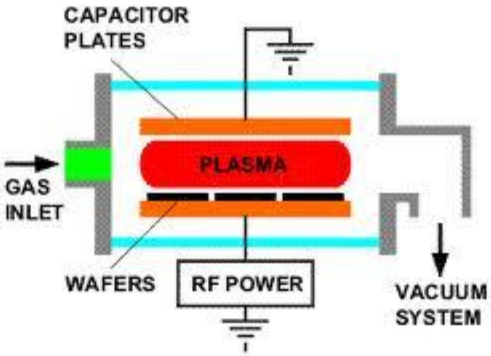
Sun, Stars, Interstellar Material, Lightning Bolt, etc

A few examples

1- Plasma Ball

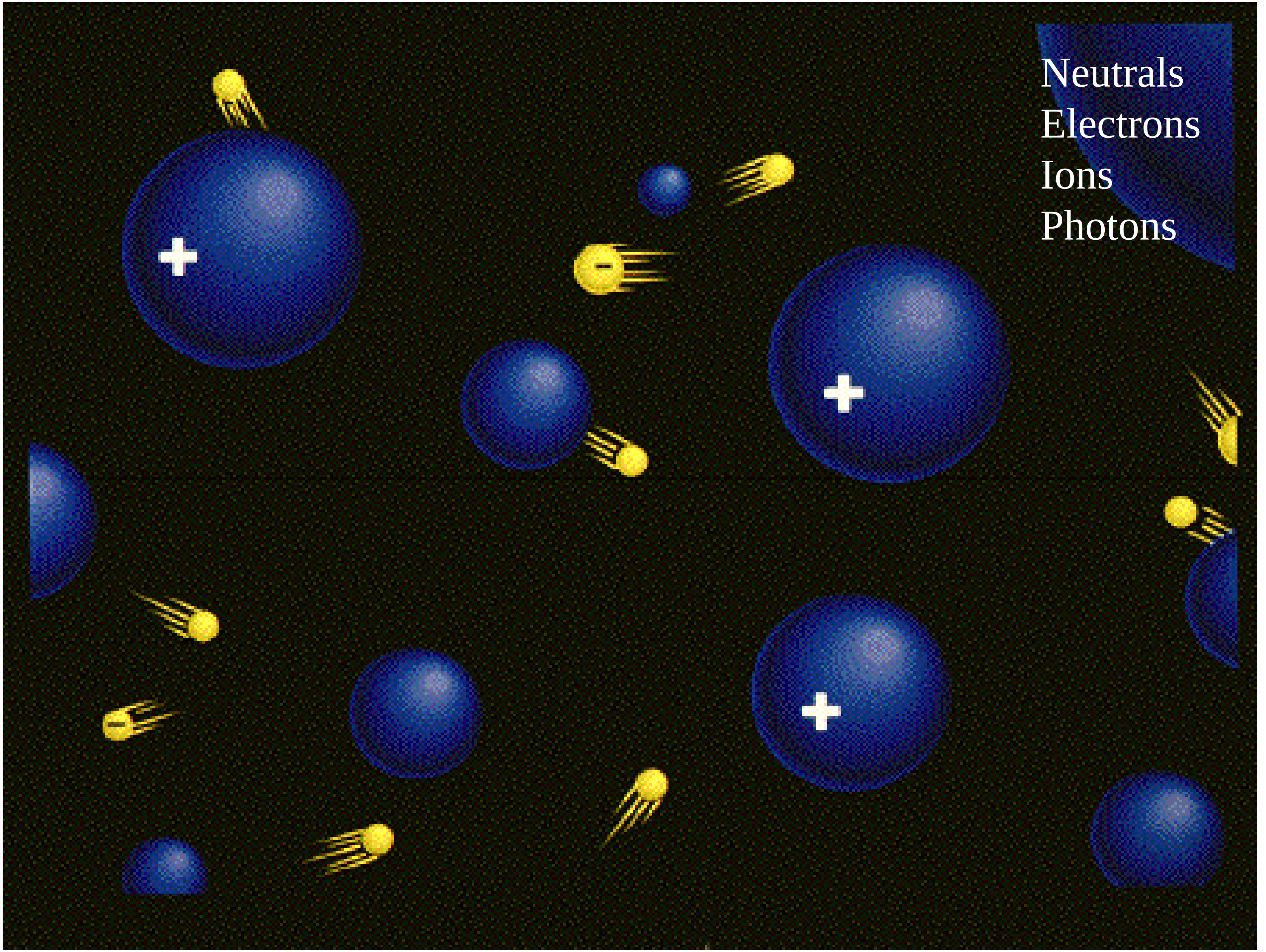


2- Capacitative RF Plasmas



3- Tore Supra Tokamak

Tore Supra is one of the largest *tokamak* in the world located in France. Its main features are its superconducting toroidal magnets and its actively cooled first wall


Neutrals
Electrons
Ions
Photons

Neutrals:

Atoms(translational and electronic energy states)

Molecules (translational, electronic, vibrational and rotational energy levels)

Ions: Same as the neutral

Electrons:

mass=9.11 x 10^{-31} Kg, Charge=1.602 x 10^{-19} C and

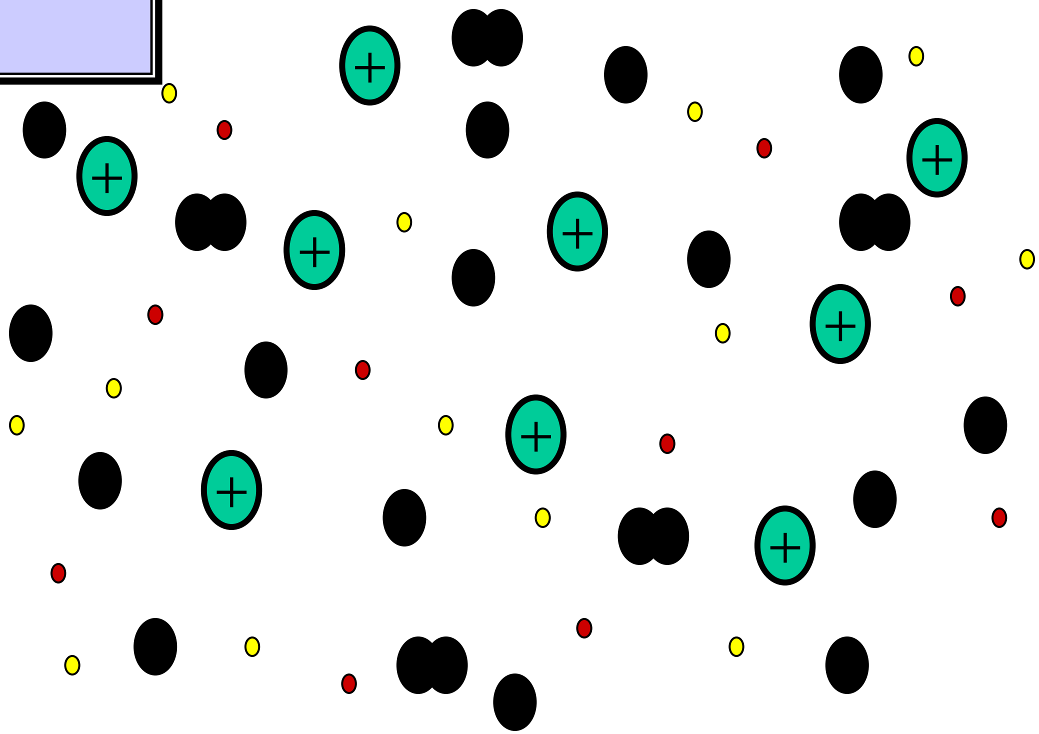
$F=e(E+v \times B)$ Lorentz Force

Photons:

$E=h\nu$, $c=\lambda\nu$ and $p=h/\lambda$

$h=6.626 \times 10^{-34}$ JS

$$E = \frac{3}{2}kT = \frac{1}{2}m\overline{v^2}$$



$$T = f(v)$$

Eelectrons:

m_e=9.1 x 10^{-31} Kg

k= 1.38 x 10^{-23} J/K Boltzmann's Constant

1 eV = 1.6 x 10^{-19} J = 7,740 K = 6 x 10^{5} m/s

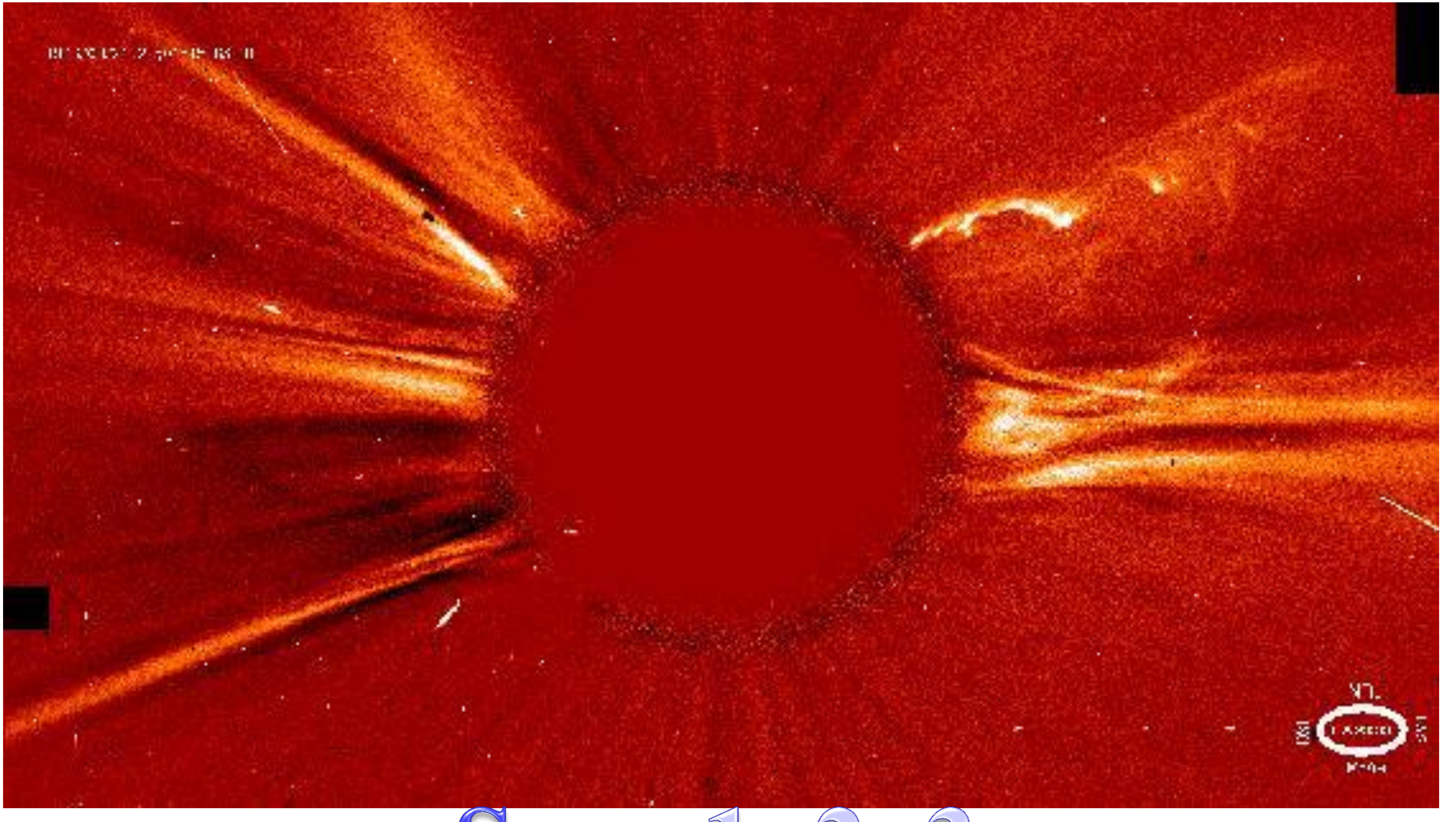
Room Temperature: 293 K = 1.2 x 10^{5} m/s

Plasma Applications

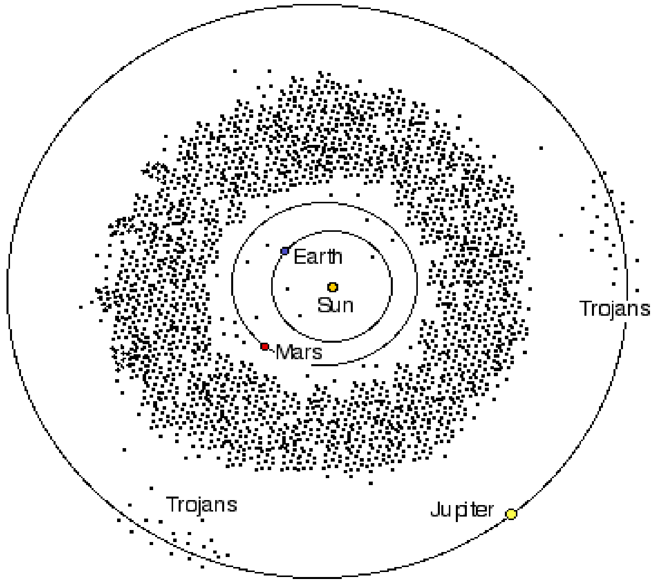
Natural

Man Made Plasmas

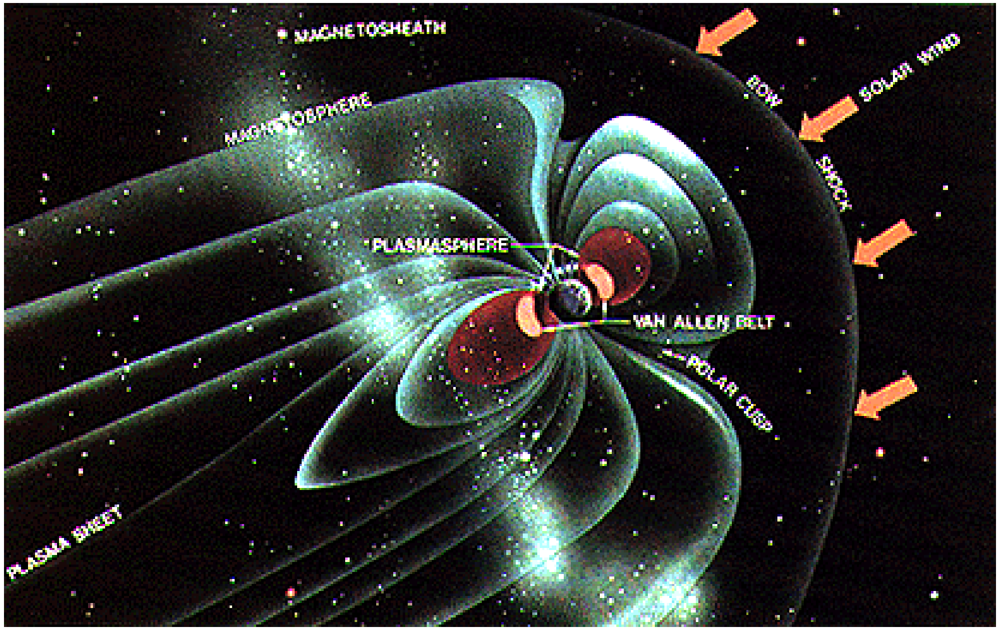
Natural Plasmas



Sun: 1, 2, 3



More Than 99.99% of the universe is in the plasma State



Van Allen Belt

AURORA: 1, 2, 3

Man-Made Plasmas

Advantages:

Higher temperatures and energy densities compared to gases generated by ordinary chemical reactions → (more energetic electrons, atoms, ions, photons, radicals and reactive neutral species)

Home-Made Plasmas

Plasmas Generation

Coupling

Breakdown

Maintenance

DC, AC, RF, MW Power Supplies

Capacitors

Focused Laser Beam

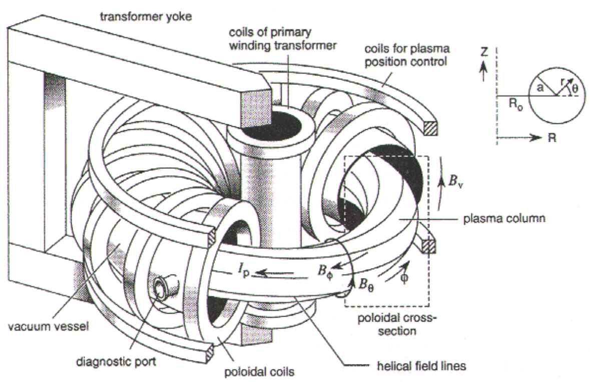
Electron and ion beams

Solid (e.g. iron, copper, …)

Liquid (Mercury, …)

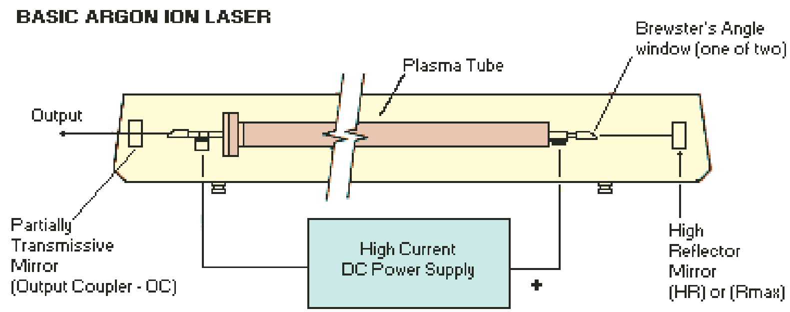
Gas (Ar, H_2, SF_6, …)

Man-Made Plasmas

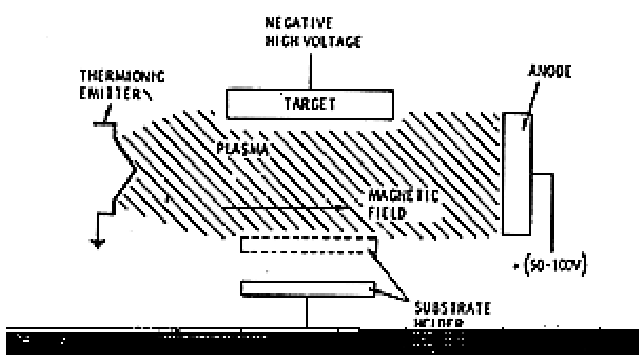


Fusion

Textor Fusion Reactor (Julich, Germany): Inside and Plasma

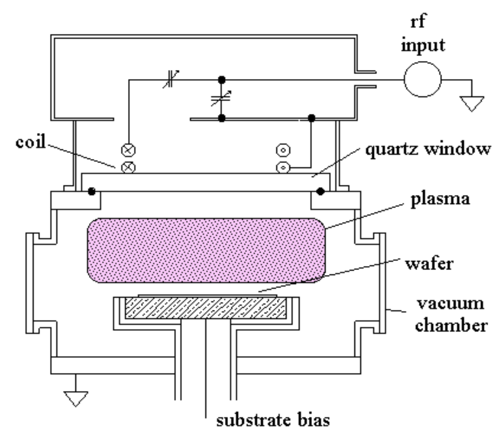


Laser

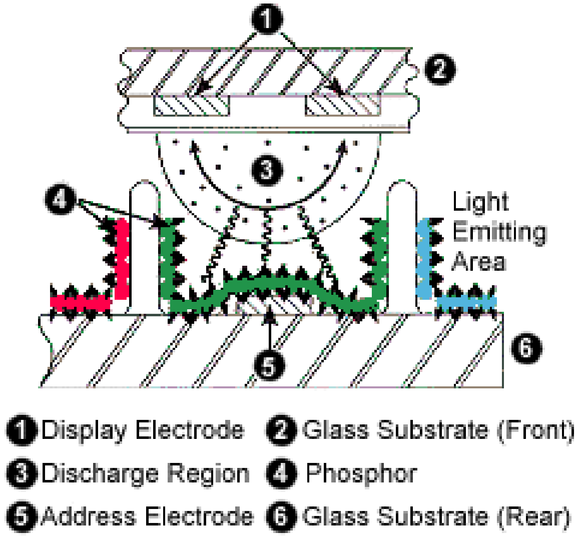


Deposition

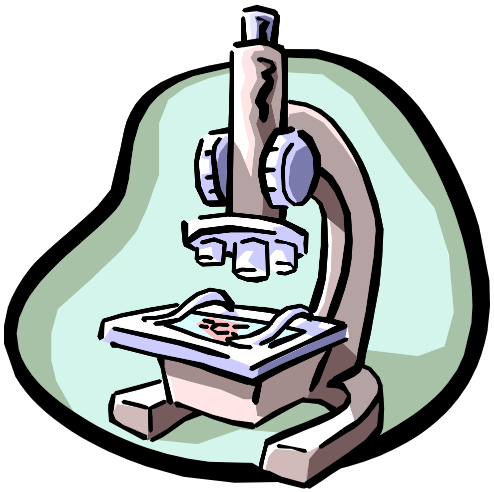
Animation, atomic layer, Nano-tech



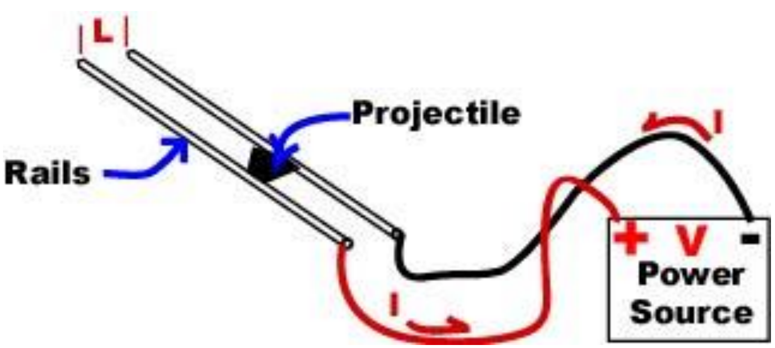
Etching



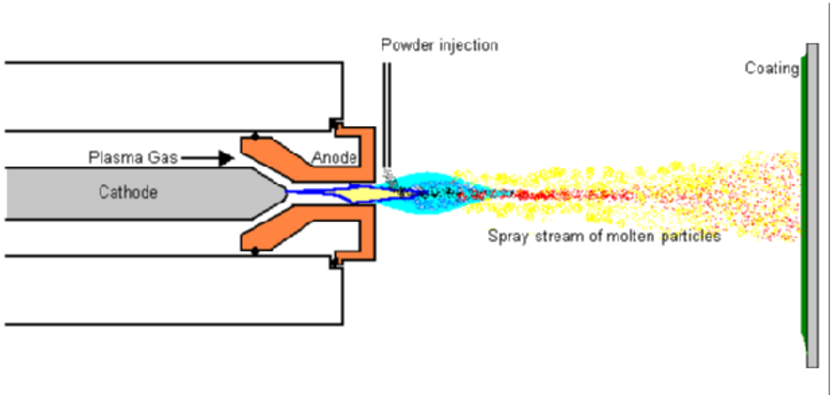
[Plasma Display Panel (PDP)]



[Plasma in Medical Applications]



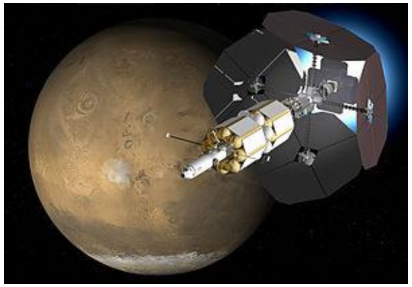
Railgun

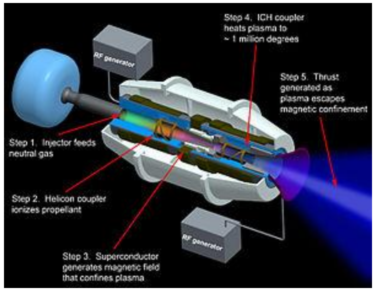


Plasma Spraying

1- NASA VASIMIR

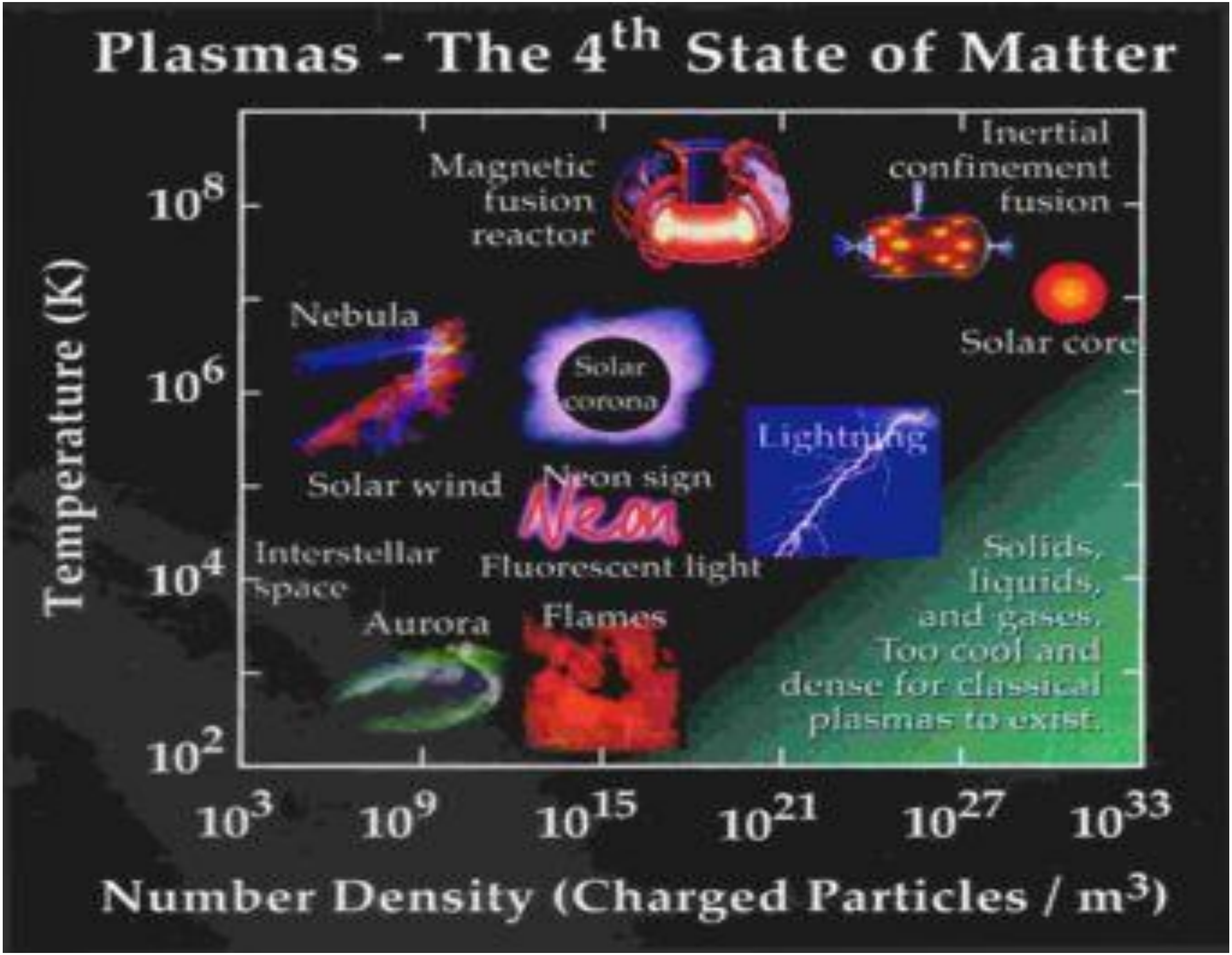
Variable Specific Impulse Magnetoplasma Rocket
An electro-magnetic thruster for spacecraft propulsion





2- Metallisation Arcspray

3- Flyback Driven Plasma Discharge



Plasmas - The 4th State of Matter
Temperature (K)
10^8
10^6
10^4
10^2
Magnetic fusion reactor
Inertial confinement fusion
Nebula
Solar corona
Solar core
Lightning
Solar wind
Neon sign
Neon
Interstellar space
Fluorescent light
Aurora
Flames
Solids, liquids, and gases. Too cool and dense for classical plasmas to exist.
10^3
10^9
10^15
10^21
10^27
10^33
Number Density (Charged Particles / m^3)

EE 403/503 Website

Qualifying Exam for Graduate Students

Project # 1

Search for topics in plasma areas and find one that you are mostly interested and would like to study for the rest of the semester.

Email me a topic before the deadline, 1/22/2013.

Next week in the class, we will discuss about your selected topics.