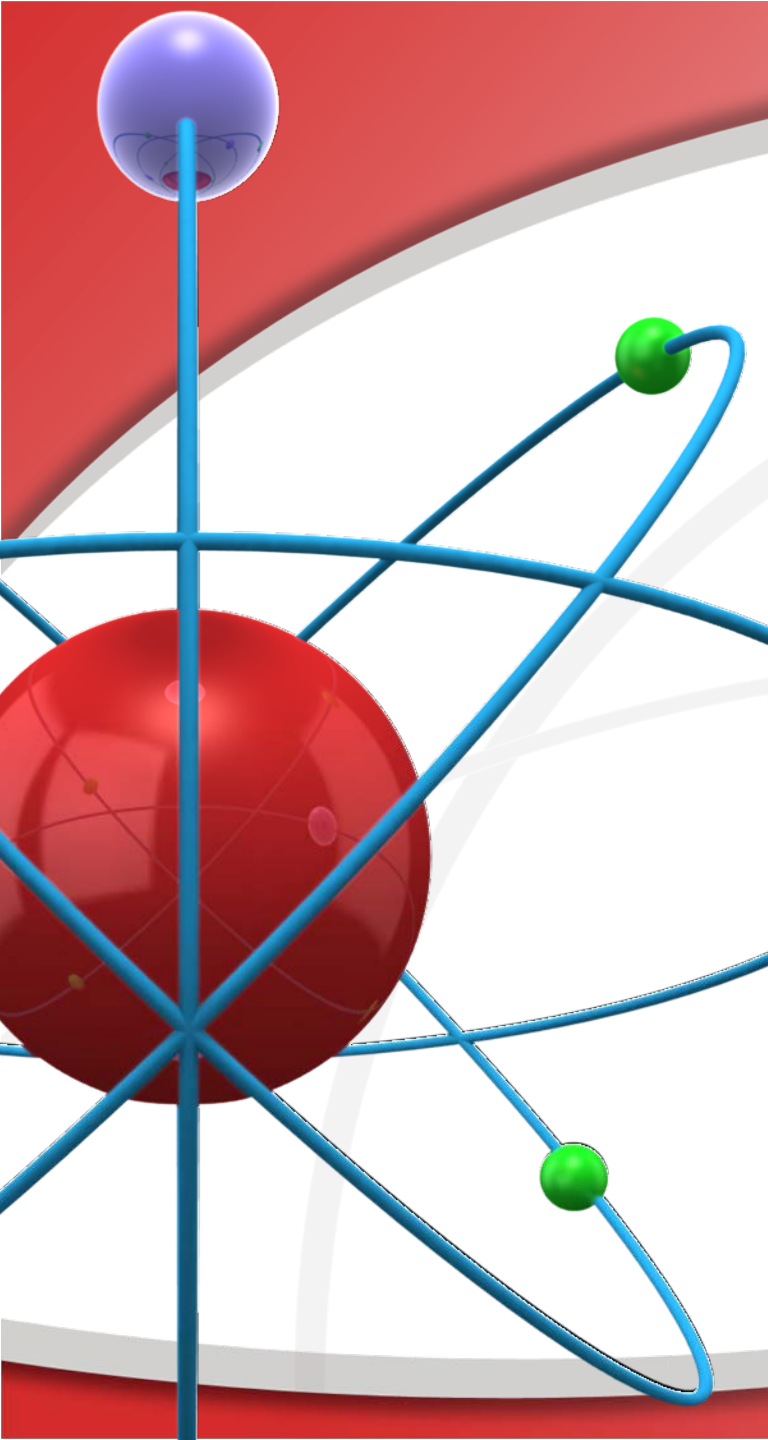




Plasma Physics 101

Cyndi Hernandez, Ph.D.

Jorge Carmona-Reyes, M.S.

Truell Hyde, Ph.D.

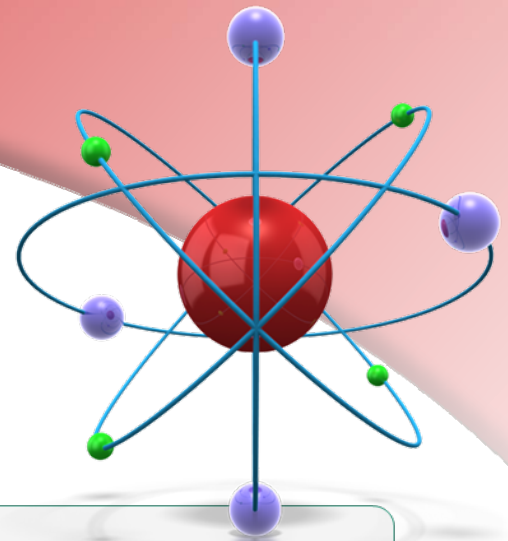
Baylor University



Center for Astrophysics, Space
Physics, and Engineering Research

Baylor.edu/CASPER

•Agenda



1st

Plasma and the TEKS

2nd

What is Plasma?

3rd

Where is Plasma?

4th

What kind of scientists work with plasma?

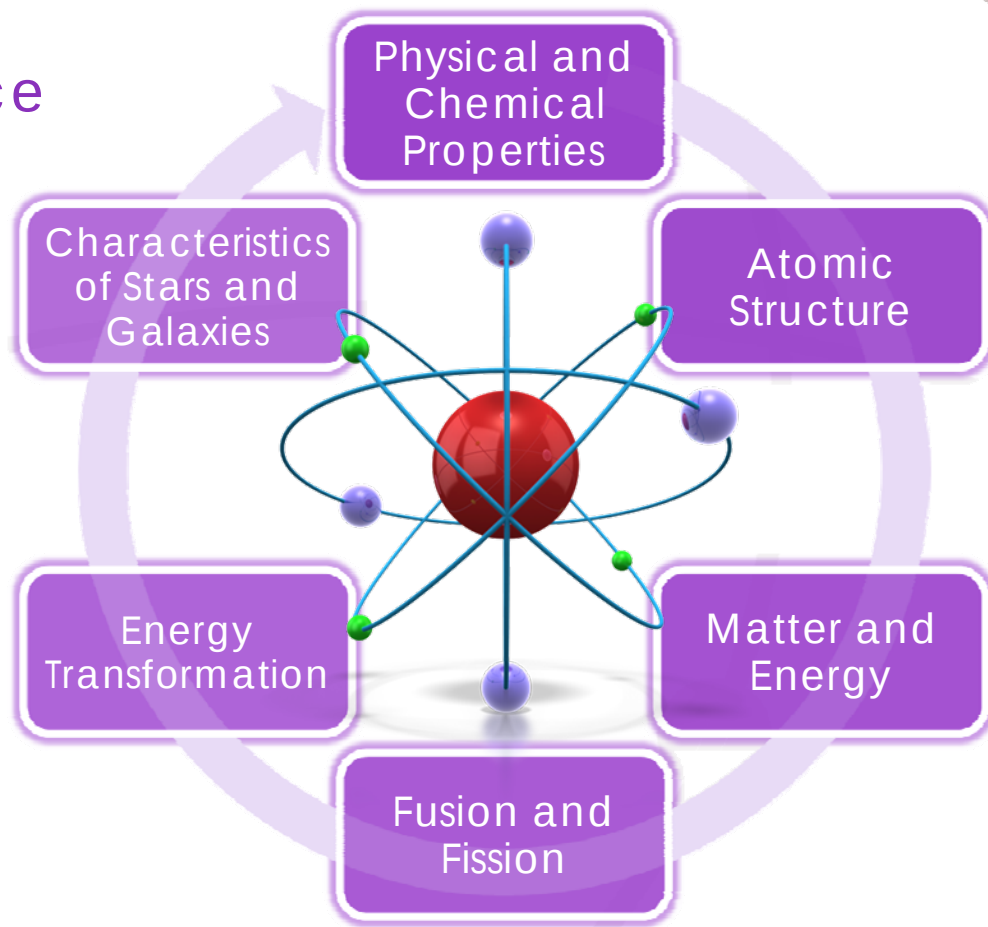
5th

Plasma Labs



•Plasma and the TEKS

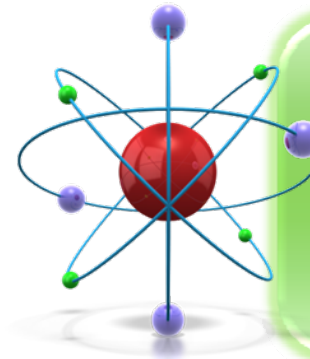
Middle School Science
Earth and Space Science
Astronomy
Chemistry
Physics



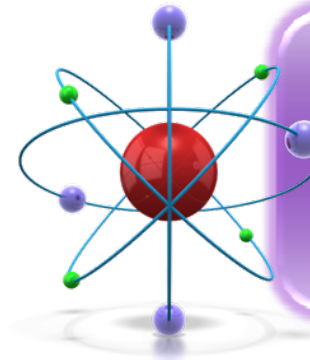


•Why should I make sure my students understand plasmas?

- Plasma technology is one of the fastest growing innovations in science. Many of the highest paying jobs over the next ten years will depend on the ability to understand and utilize this technology.
- The scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are gathering strength.



85% of measured growth in US income per capita was due to technological change.

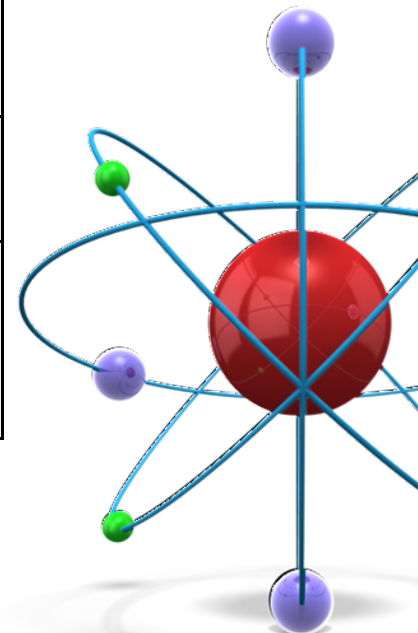


Our workforce is in direct competition for jobs with lower-wage workers around the globe.



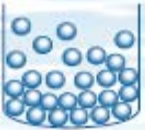
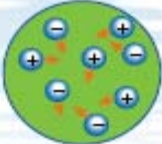
•Why should I make sure my students understand plasmas?

Topic	Application
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
Plasma Applications	– Plasmas can be used to build computer chips and to clean up toxic waste.

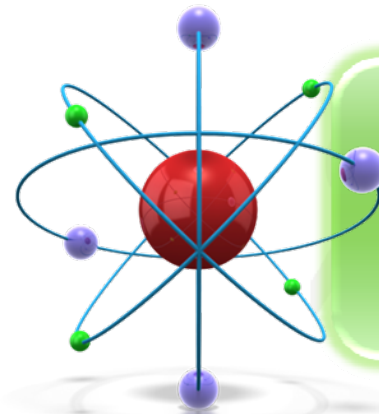


•What is Plasma?

A plasma is referred to as the 4th state of matter

States of Matter			
Solid	Liquid	Gas	Plasma
Example Ice H_2O	Example Water H_2O	Example Steam H_2O	Example Ionized Gas $H_2 \rightarrow H^+ + H^+ + 2e^-$
Cold $T < 0^\circ C$	Warm $0 < T < 100^\circ C$	Hot $T > 100^\circ C$	Hotter $T > 100,000^\circ C$ (> 10 electron Volts)
			
Molecules Fixed in Lattice	Molecules Free to Move	Molecules Free to Move, Large Spacing	Ions and Electrons Move Independently, Large Spacing

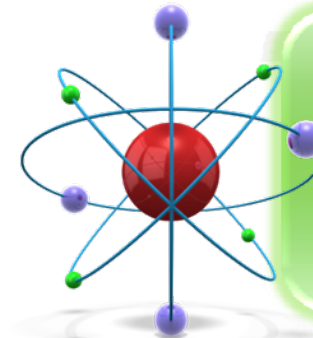
What causes the change from one state to another?



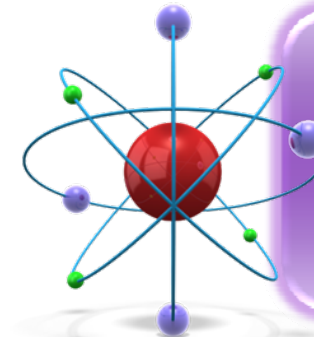
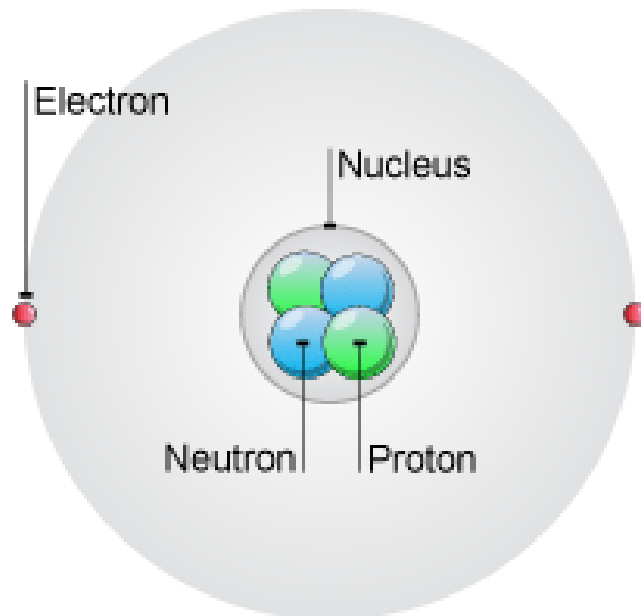
More than 99% of the mass of the universe is in the plasma state.

•What is Plasma?

- A plasma is an ionized gas.
- Atoms consist of a nucleus containing protons, neutrons, and electrons that orbit the nucleus.

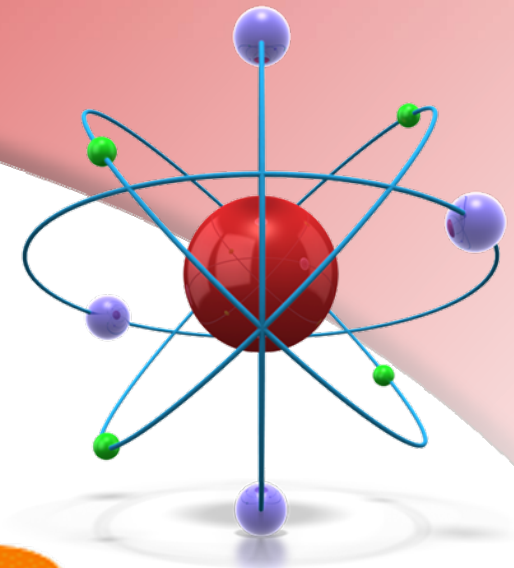
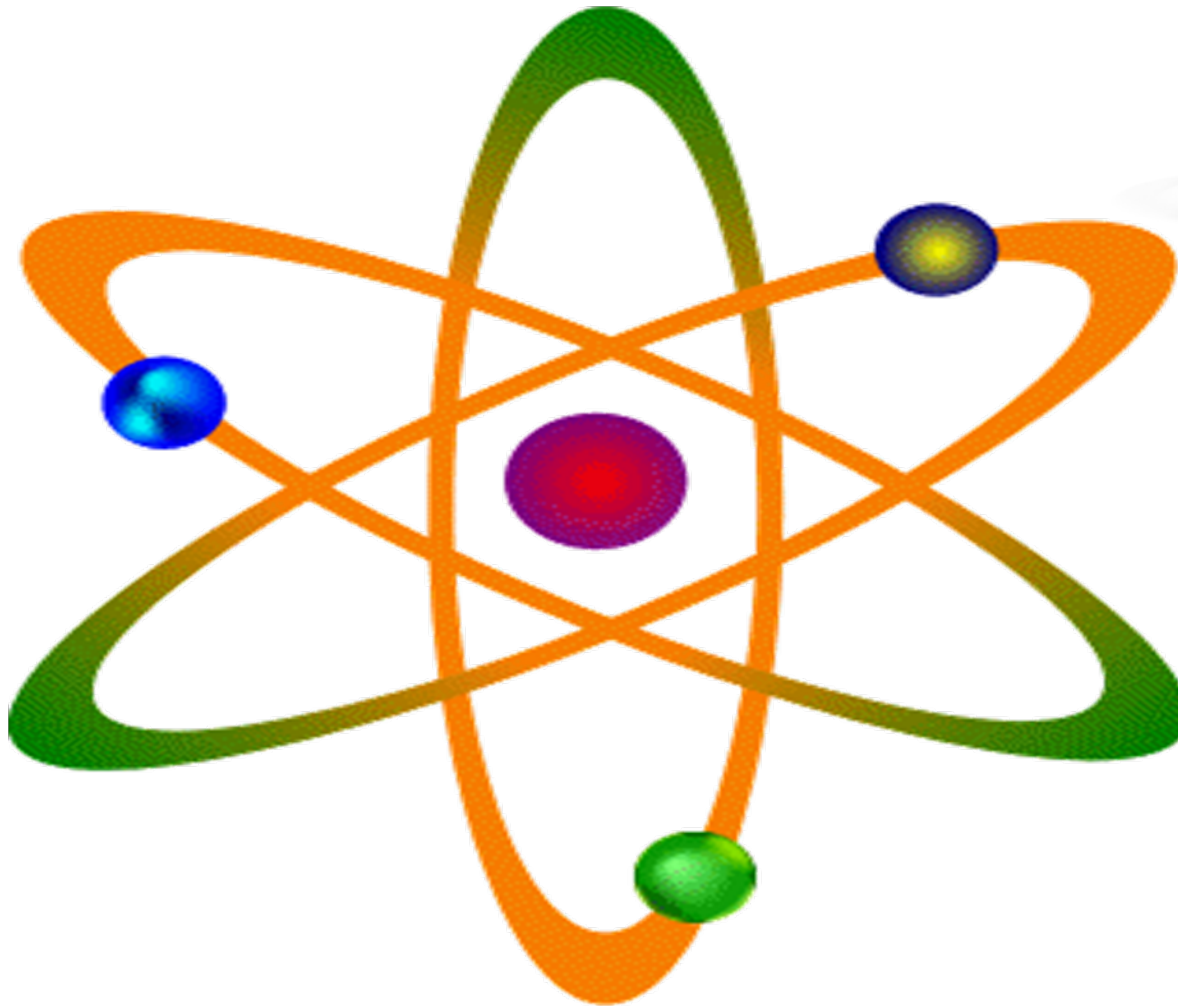


Atoms have the same number of + (proton) and – (electron) charges so they are electrically neutral.



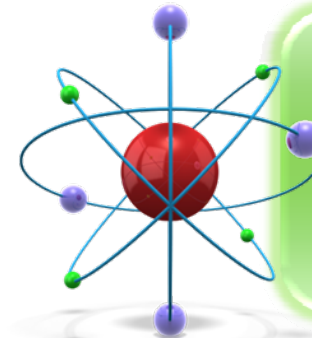
It is easier to create ions in a gas due to its lower density as opposed to liquids or solids.

- Protons, neutrons, and electrons orbit the nucleus of an atom.



•What is Plasma?

- A plasma is an ionized gas.
- When an electron is stripped away from the atom, an ion is formed, which has a positive charge.



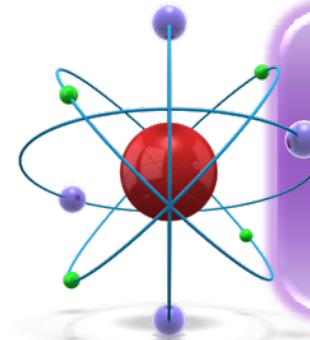
Not all ionized gases are called plasmas.



GAS

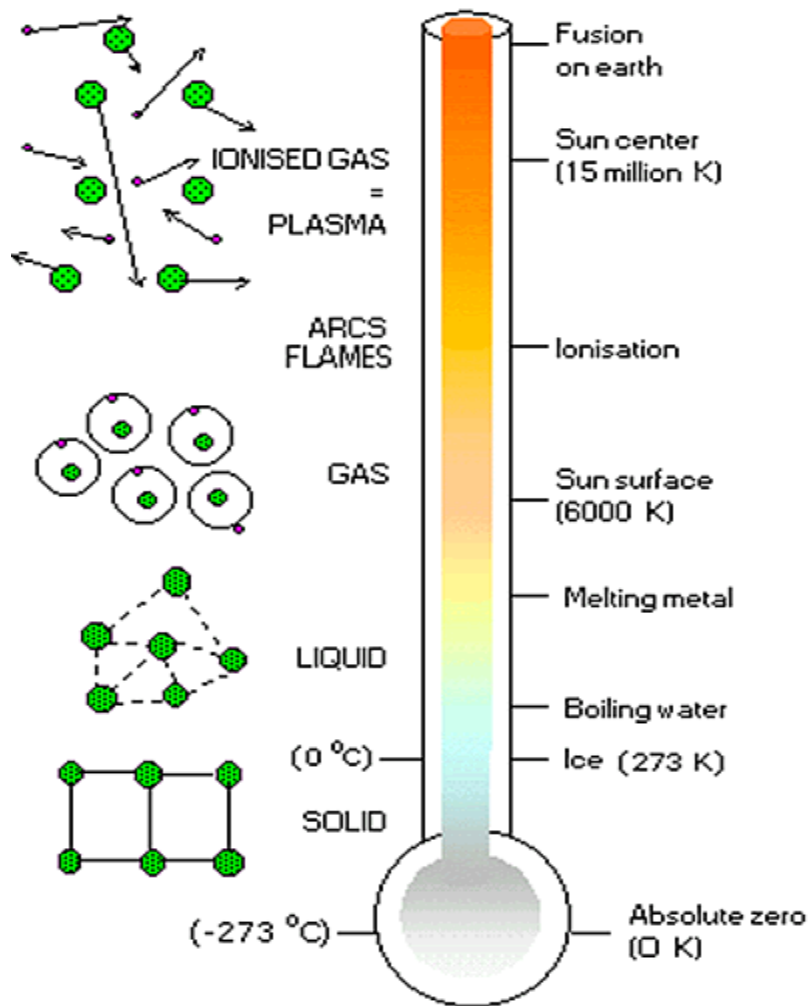


PLASMA

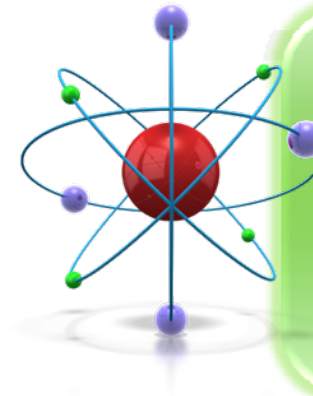


A plasma contains a significant number of electrically charged particles to affect its electrical properties and behavior.

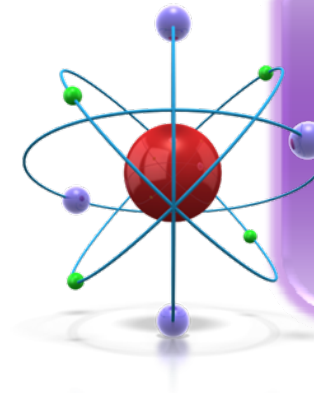
•What is Plasma?



Courtesy CEA, France



Changing states of matter is about changing densities, pressures, temperatures, and other physical properties.

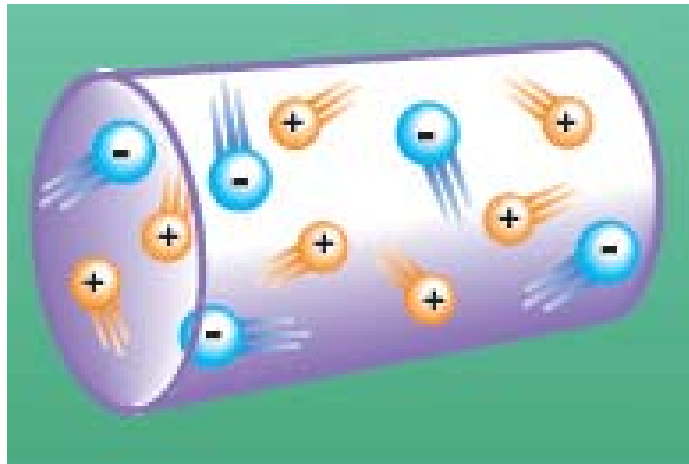


One compound or element can move from phase to phase, but still be the same substance.

•What is Plasma?

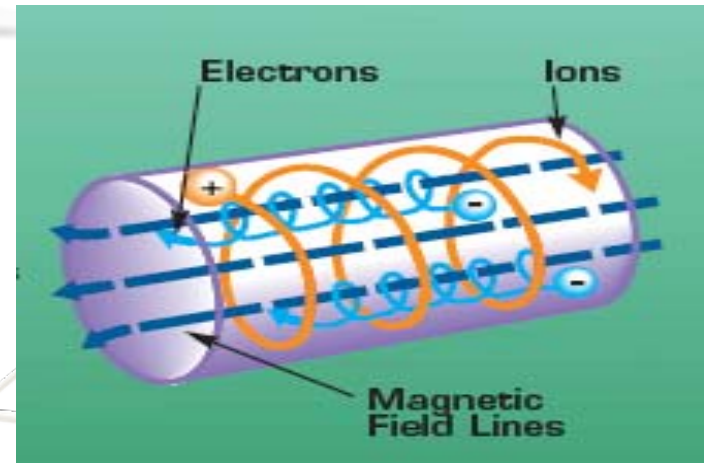
Ions will react to any electrostatic or magnetic fields they encounter.

MOTION OF CHARGED PARTICLES WITHOUT MAGNETIC FIELD



- Particles bounce off wall like ordinary gas
- Plasma loses energy
- Container gets hot

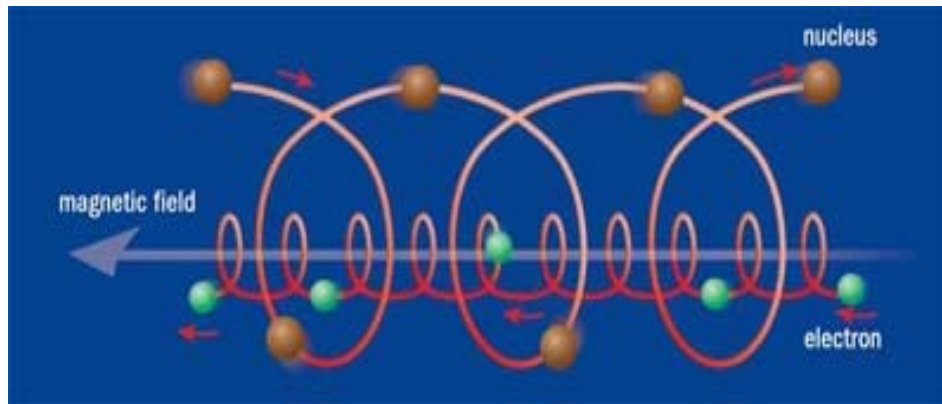
MOTION OF CHARGED PARTICLES WITH MAGNETIC FIELD



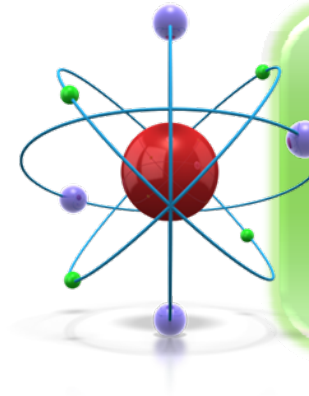
- Charged particles spiral around magnetic field lines
- Plasma follows magnetic field lines and is insulated from container.

•What is Plasma?

- Ions and electrons spiral in opposite directions in a magnetic field.

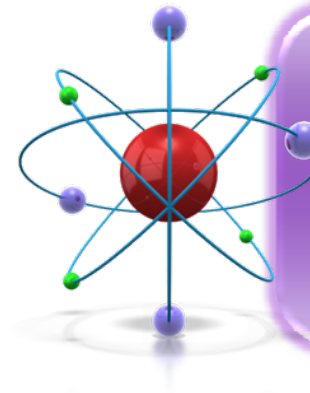


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Ions carry a positive charge.

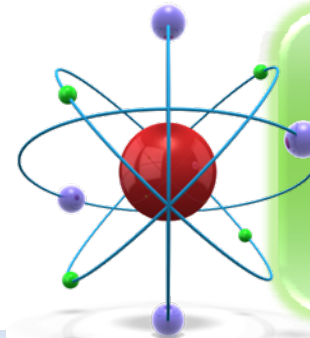
Electrons carry negative charges.



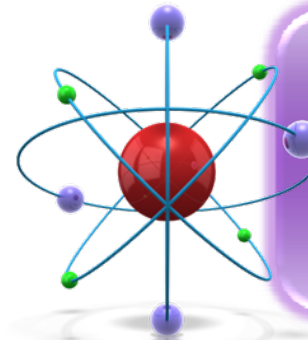
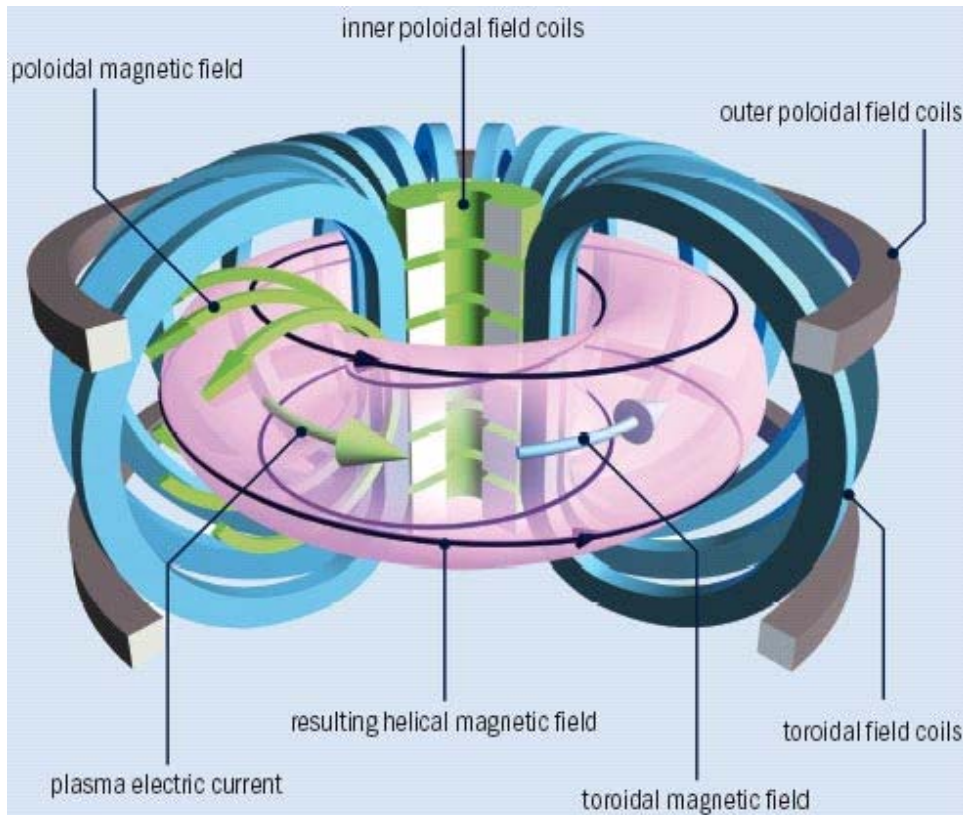
Magnetic fields are used for confinement since no solid material could withstand the extremely high temperature of the plasma.

•What is Plasma?

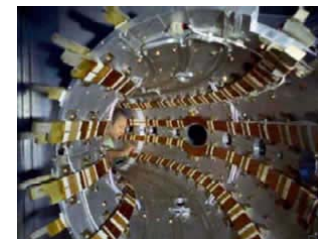
- The temperature of a plasma is increased if it is compressed rapidly by increasing the confining magnetic field.



A tokamak is a type of machine that uses a magnetic field to confine a plasma in the shape of a torus(donut).

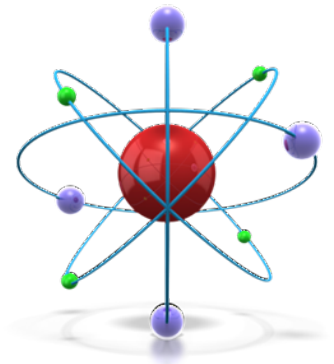


The magnetic fields in the chamber compress the gas which helps increase the temperature.



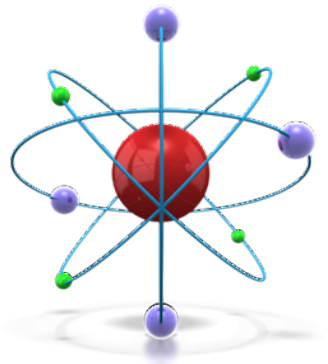
•Where is Plasma?

- Lightning



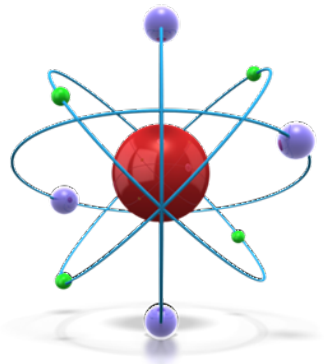
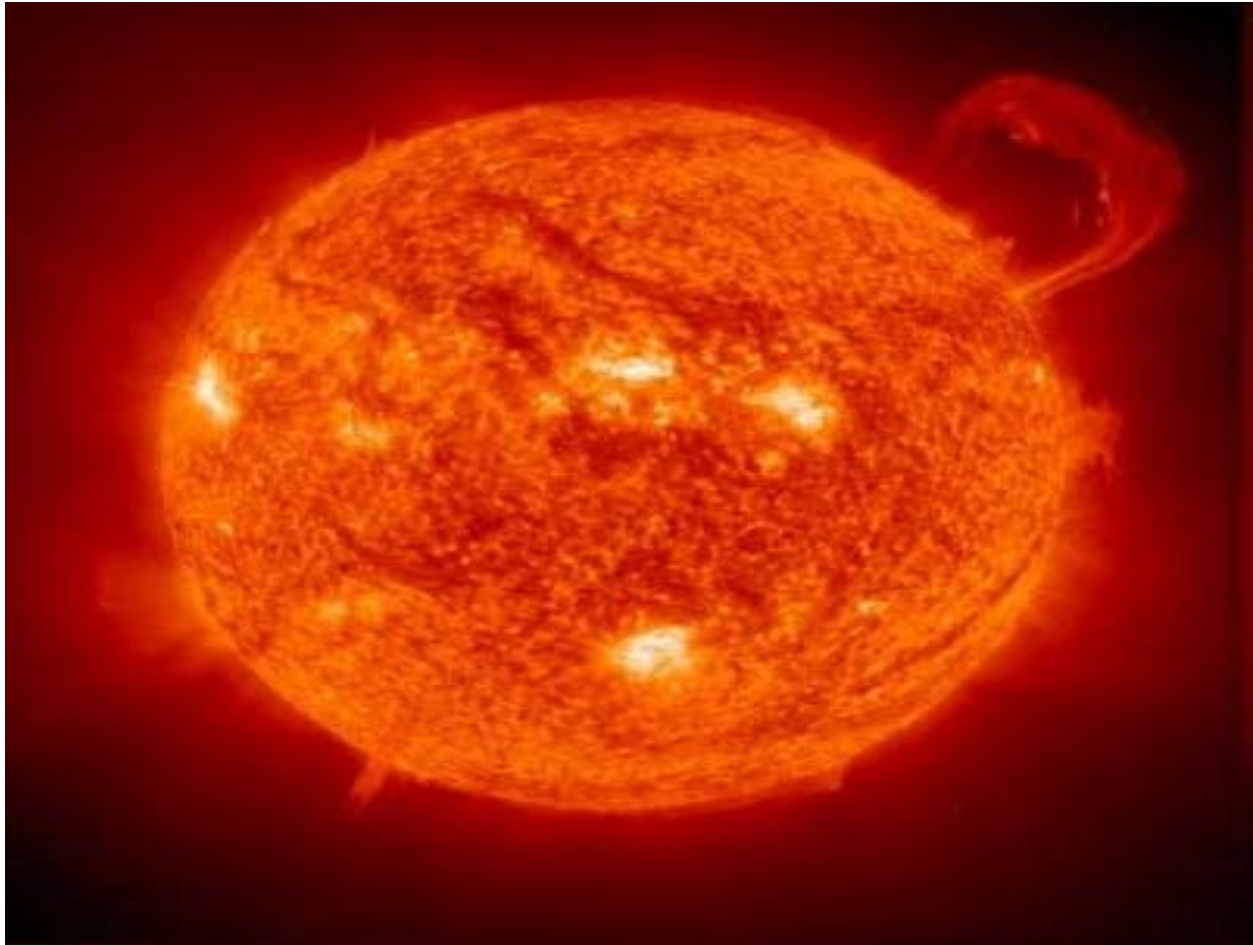
•Where is Plasma?

- Aurora



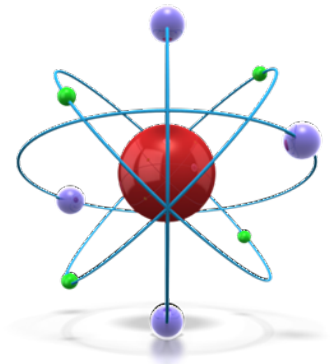
•Where is Plasma?

- Stars and our Sun



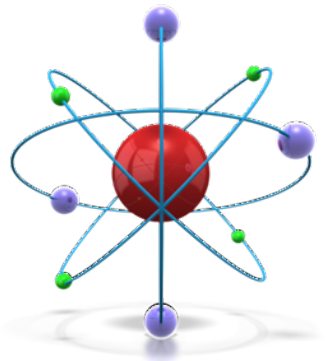
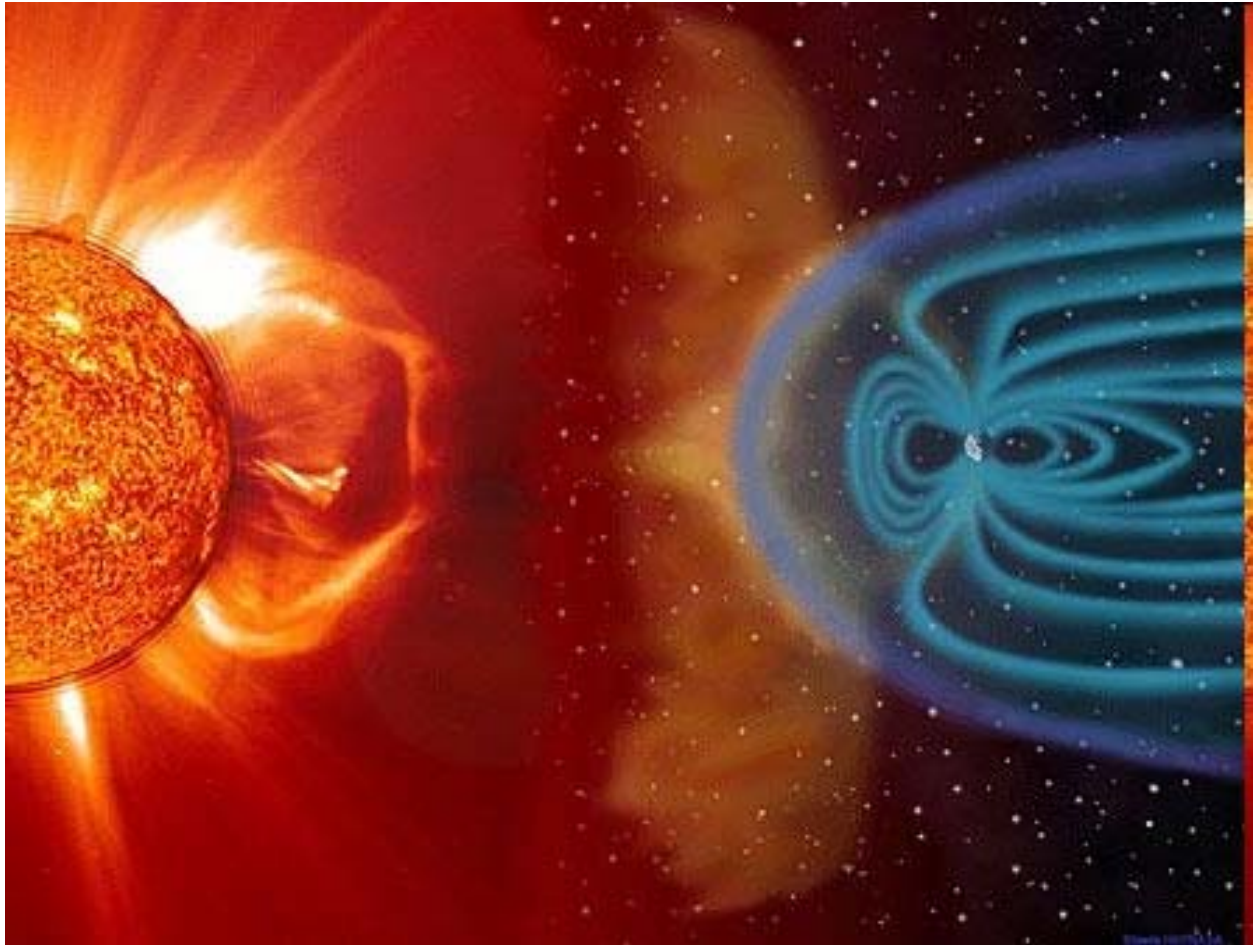
•Where is Plasma?

- The Ionosphere



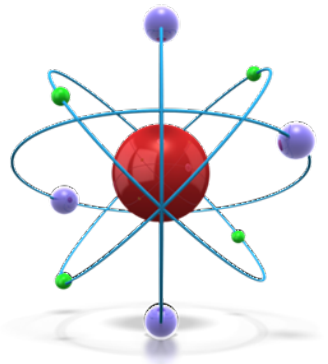
•Where is Plasma?

- The Solar Wind



•Where is Plasma?

- Interstellar Gas Clouds (Nebula)

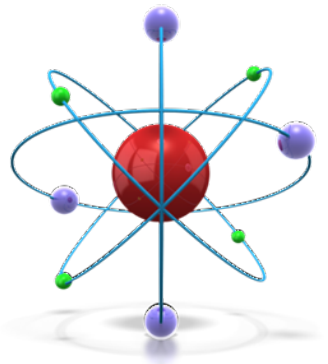


•Where is Plasma?

- Comet Tails



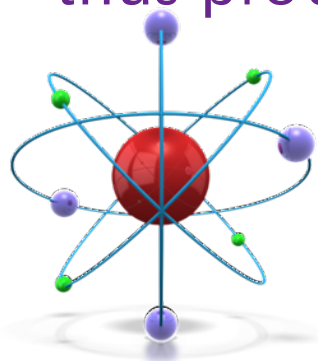
© 1996 Jerry Lodriguss





•Where is Plasma?

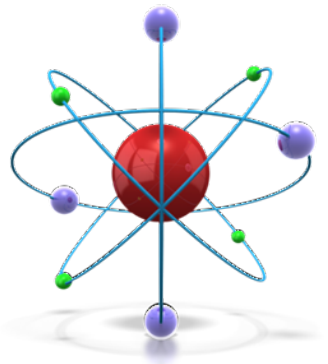
- **Plasma balls** contain mixtures of helium, neon, argon, and other gases.
- Once the power is switched on, some of the neutral gas molecules have one or more electrons ripped from them by the electric field generated, thus producing plasma.





•Where is Plasma?

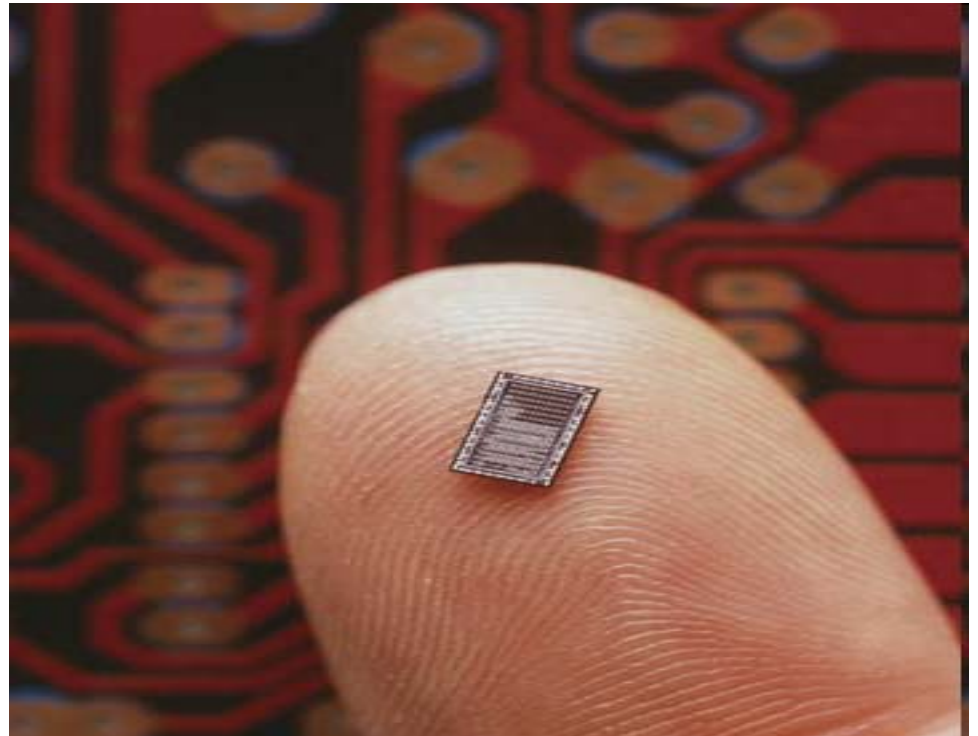
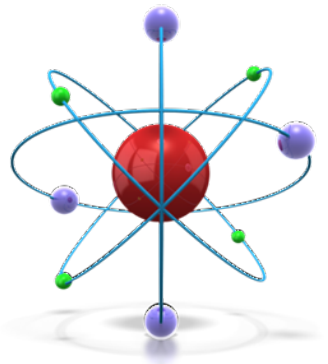
- **Gases in Discharge Tubes** (fluorescent lamps and neon signs)





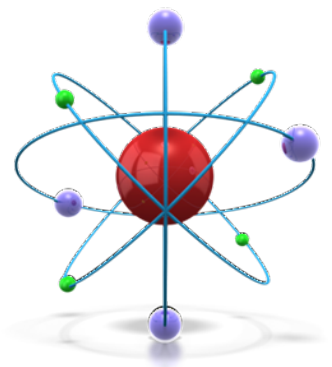
•Where is Plasma?

- Plasma is used to make **Computer Chips**



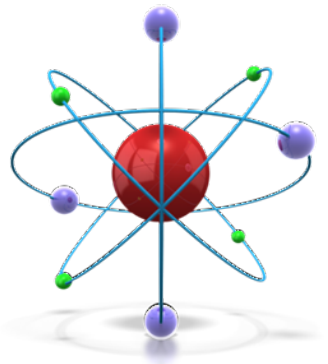
•Where is Plasma?

- Flat Panel Monitors



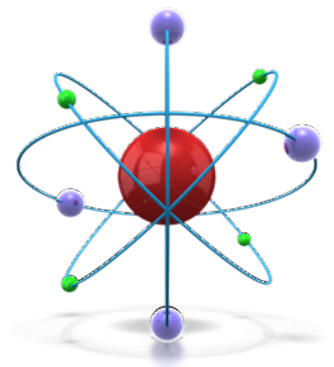
•Where is Plasma?

- **Plasma Cutting Robots** cut dense materials with precision and speed by using a high-velocity stream of gas (plasma) which flows through a narrow torch and melts the product.



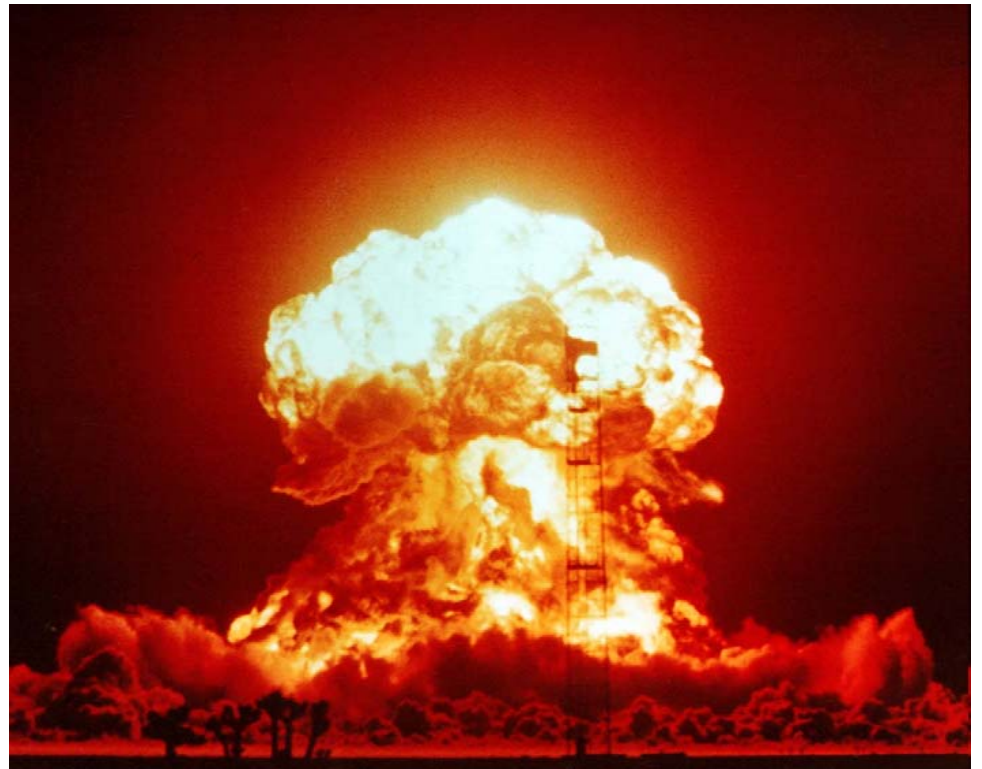
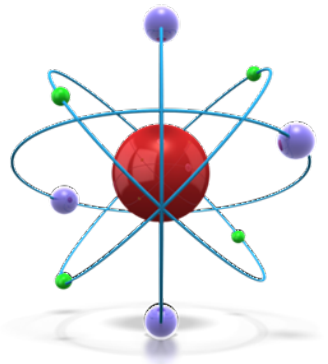
•Where is Plasma?

- Welding Arcs



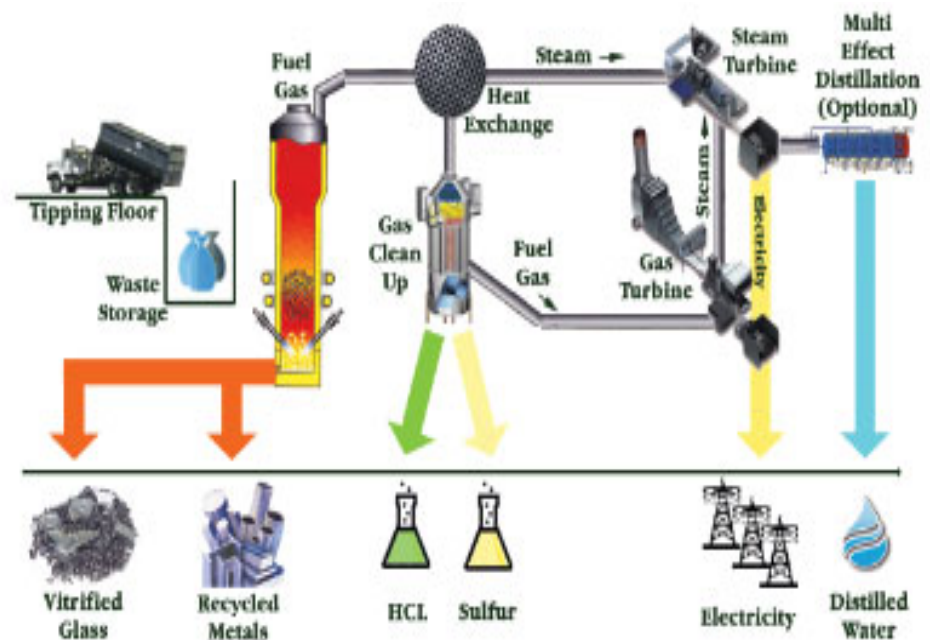
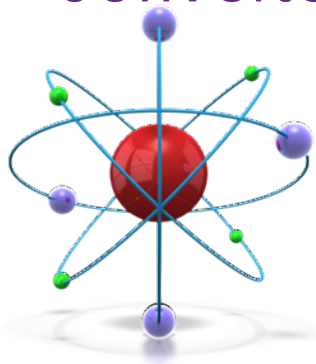
•Where is Plasma?

- The fireball made by a nuclear weapon



•Where is Plasma?

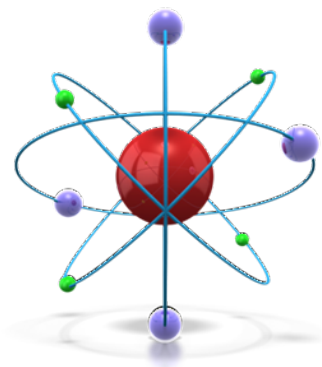
- **Plasma Gasification**
obliterates garbage by heating it up to 10,000° Celsius leaving a byproduct of gas and a minimal amount of solid slag. The glass-like slag can be used in roads, jewelry, and other applications. The gas and steam can be converted into energy.



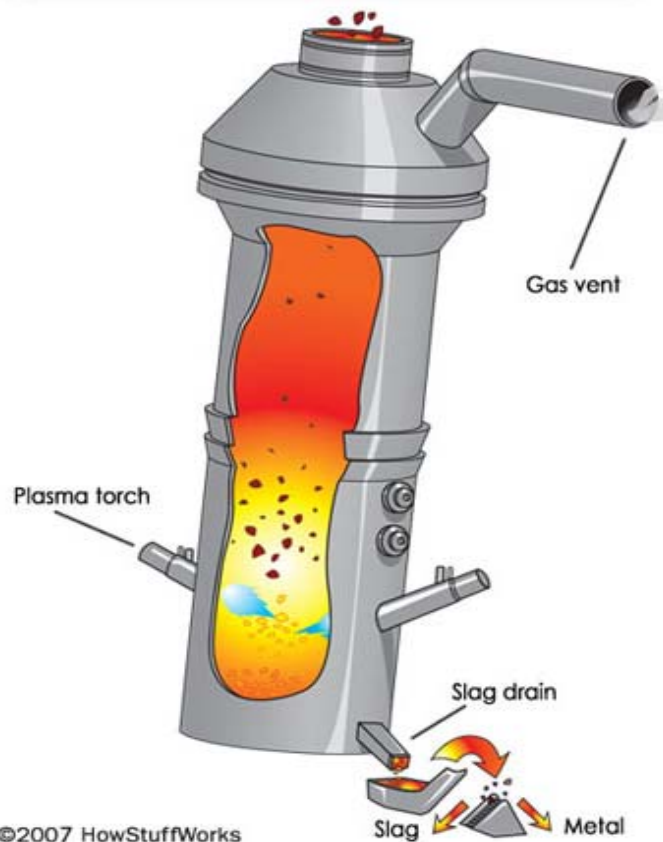
Source: Wikipedia, Eco-Tech

•Where is Plasma?

- **A Plasma Torch** is used for hazardous waste treatment and disposal.
- Treated by the high temperatures, hypodermic needles can be melted and the plastic squirts vaporized and carbonized.



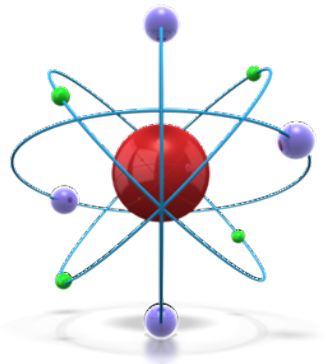
How Plasma Converters Work: Plasma furnace



©2007 HowStuffWorks

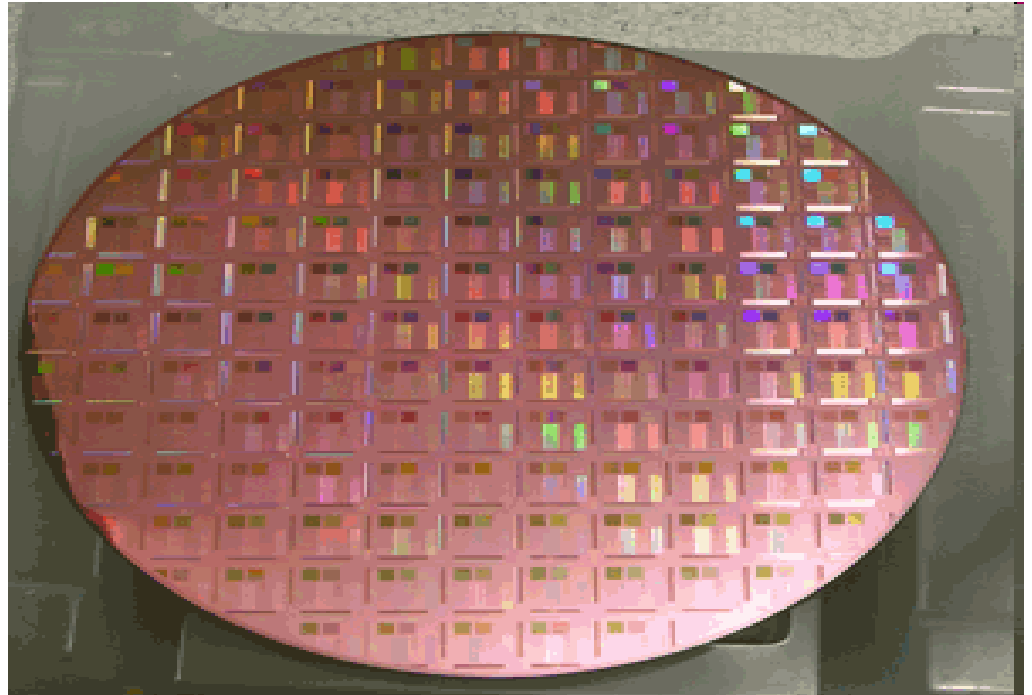
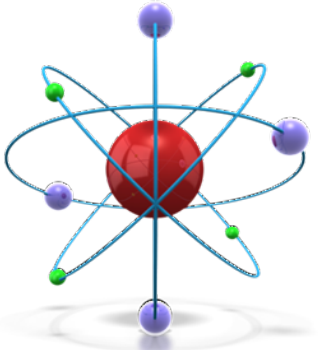
•What kind of scientists work with plasma?

- **Astronomers** study plasma, since it makes up 99% of the visible matter in the Universe.



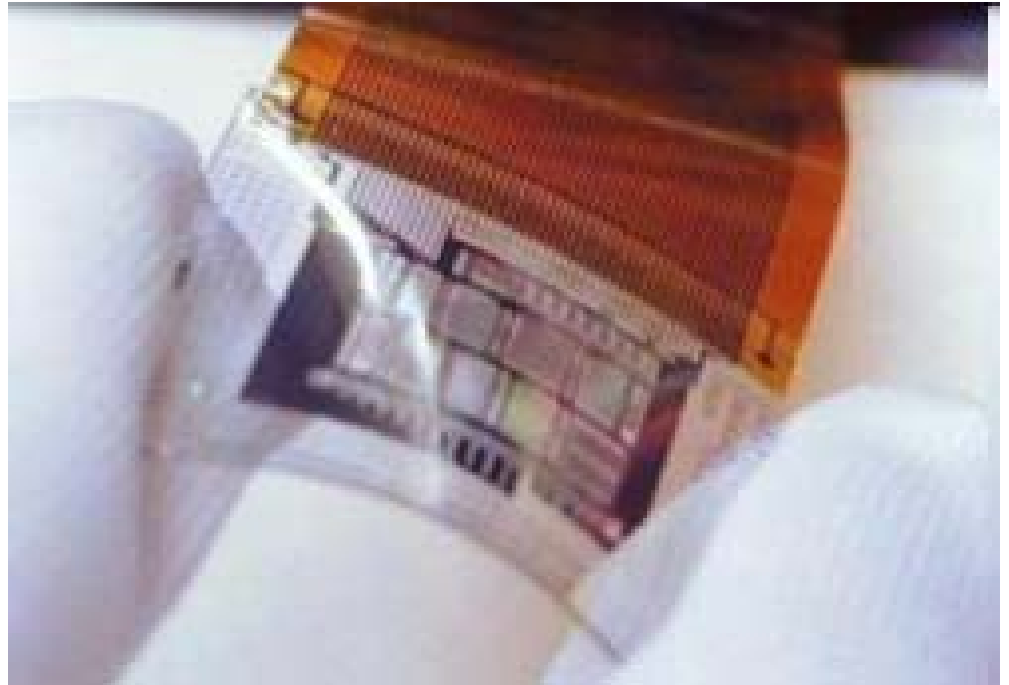
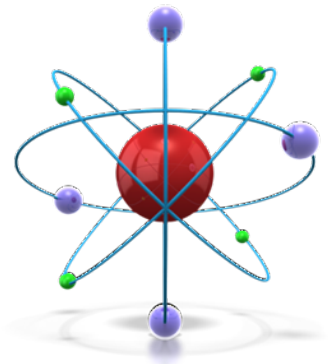
•What kind of scientists work with plasma?

- **Computer chip manufacturers** use plasma technology to make cleaner semiconductor chips.



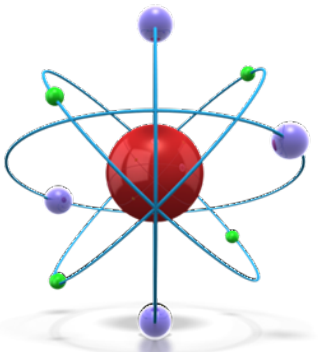
•What kind of scientists work with plasma?

- Plasma is used by manufacturers to make **computer chips.**



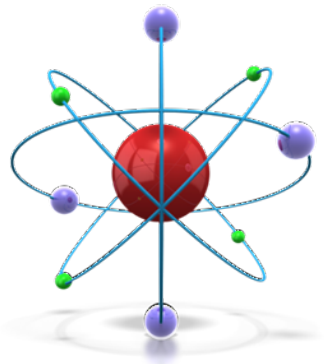
•What kind of scientists work with plasma?

- **Mechanical engineers** use plasma torches for making precise cuts.



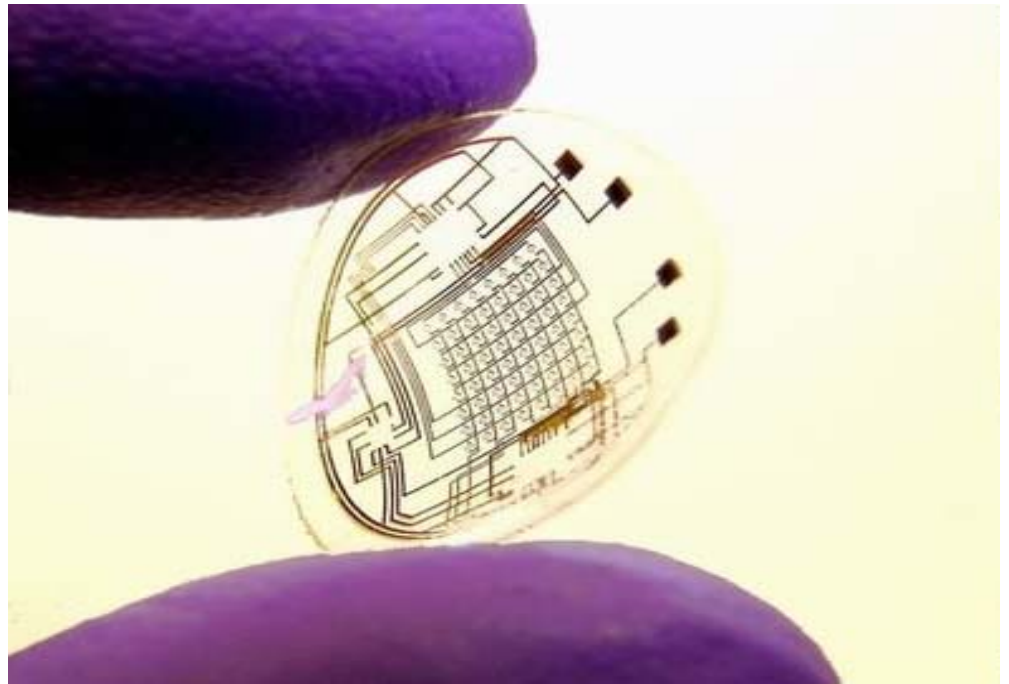
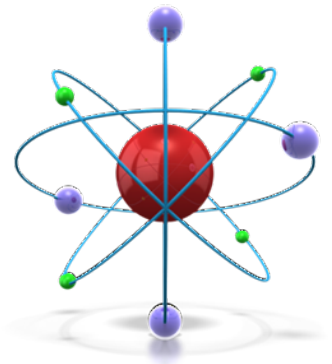
•What kind of scientists work with plasma?

- **Space scientists** plan to use plasma to propel spacecraft.



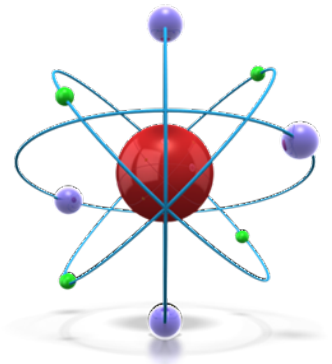
•What kind of scientists work with plasma?

- **Electrical engineers** design and build technological devices using plasma etching.



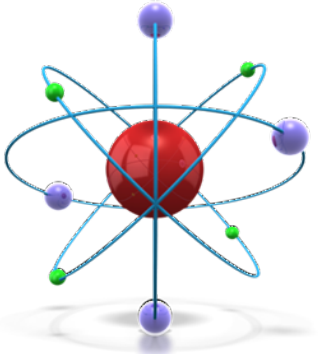
•What kind of scientists work with plasma?

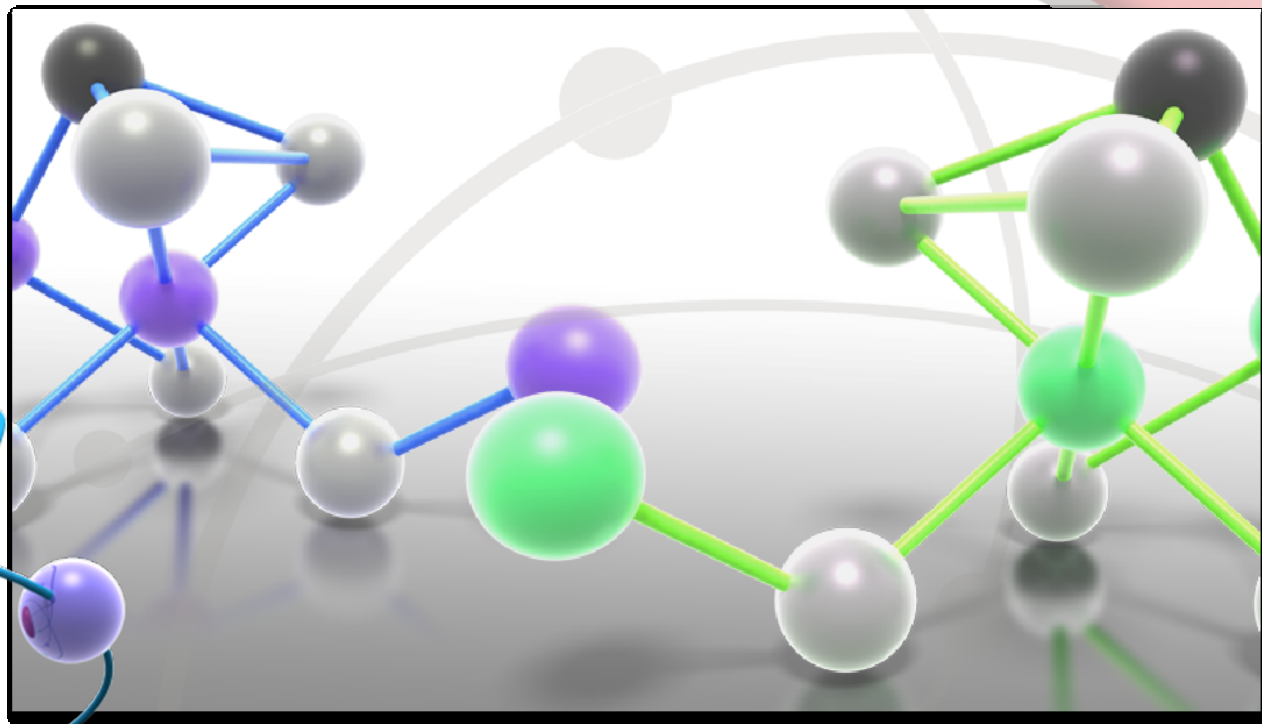
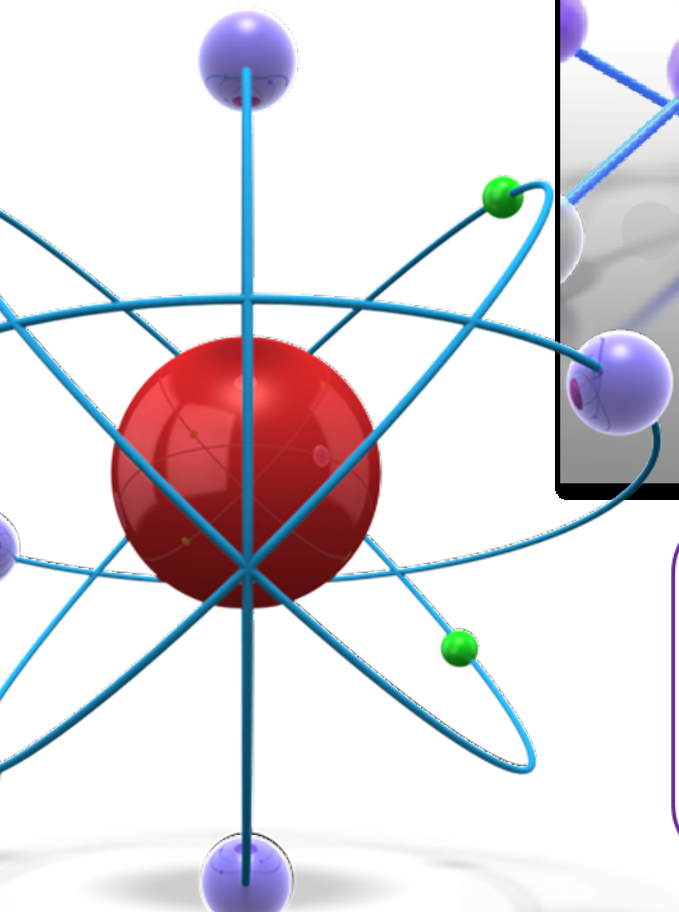
- **Aerospace engineers** design spacecraft. Plasma is used as a propulsion, computer etching, welding, etc.



•What kind of scientists work with plasma?

- **Medical personnel** use plasmas to sterilize materials.

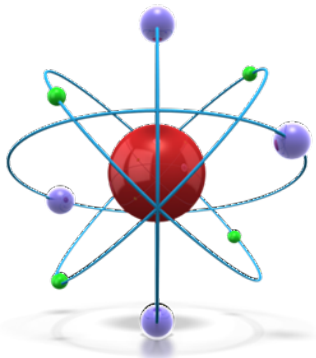




Laying a foundation for a scientifically literate workforce begins with developing outstanding K–12 teachers in science and mathematics.

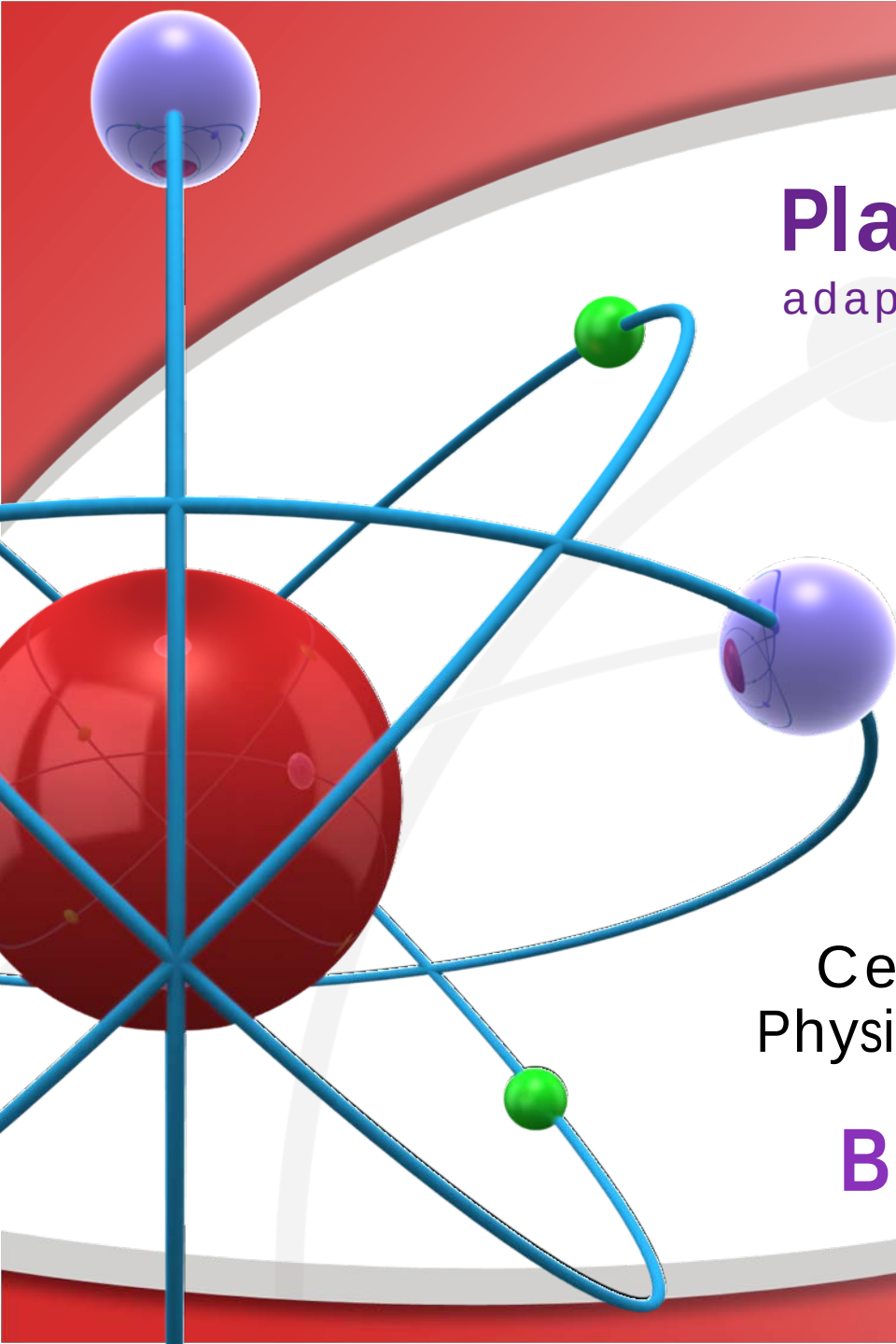
•CASPER Summer Research Experience for Teachers

- Sponsored by the National Science Foundation, Baylor University, the Physics Department, and CASPER offers elementary school, middle school and high school teachers an opportunity for active research participation with Baylor University faculty in the Center for Astrophysics, Space Physics & Engineering Research.
- 8 week program
- RET Fellows are paid up to two months of their current annualized salary for the eight week period.



For more information look at the Outreach section of our website

<http://www.baylor.edu/CASPER/>



Plasma Physics Labs

adapted from General Atomic

- Ions and Magnetics Field
- Plasmas
- Fusion Cookies
- The Science of Nothing



Center for Astrophysics, Space
Physics, and Engineering Research

Baylor.edu/CASPER