**Fusion and Plasma**

Fusion reaction takes place at very high temperatures that materials cannot exist in the form of molecules or even atoms.

At some high temperatures, molecules dissociate to atoms. Further increases in temperature cause atoms to lose electrons. The soup or mixture of positive ions and negative electrons is called **plasma**.

As a whole, a plasma is neutral, but the ions and molecules move at very high speed so that atomic nuclei approach each other at short distances of femtometers (fm also called fermi = 10^{-15} m).

**Familiar Plasma**

Plato considered earth, water, air and fire the **primal substances**. They correspond to the **four states** of matter: **solid, liquid, gas** and **plasma**.

The term plasma may not be familiar to you, but you have encountered plasma states many times. The flame in a fire, the gas in a lighted fluorescence tube, and the mixture in a glowing neon light are plasma. At a larger scale, the aurora is due to the moving of charged particles under the influence of a magnetic field. The matter in stars such as the Sun exists in the state of plasma.

Alkali metals such as sodium, potassium, and cesium have low ionization potentials, and they form plasmas at about 3,000 K. Other materials require higher temperatures to become a plasma state. No container can hold plasma and still withstand an external application of heat. Plasmas at temperature in the order of 100,000 K correspond to energies of a few eV, and these are called **cold plasmas**.

Plasmas with energy of greater than 100 eV are called **hot plasmas**. At these temperatures, nuclear fusion takes place.
Magnetic Bottles and Torus for Plasma

Therefore their motions are affected by a magnetic field. In a magnetic field, charged particles move in a spiral fashion. Positive and negative particles move in opposite directions.

As a whole, a plasma is strongly diamagnetic. Motion of the particles creates a magnetic field that cancels the magnetic field within it. The plasma can not flow out of the strong magnetic field, and it is confined in a volume by magnetic field. Such an arrangement is often called a magnetic bottle. In such a bottle, both ends have high magnetic fields, and these are called magnetic mirrors.

In the diagram below, the intensity of the magnetic field is represented by the density of the magnetic lines. The magnetic field can be generated by passing electric current in the coils. Because the plasma particles do not want to cross the magnetic lines, they are confined in the centre.

A plasma can also be confined in a toroid, which has the shape of a donut. Further development of this technique resulted in the design and construction of tokamak for the controlled thermal nuclear fusion. This link gives a virtual tokamak for anyone to try.

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