What is plasma?

In these photographs of the plasma focus current sheath, the inner electrode is located at the circle at the center of the sheath. The outer electrode is located at the circumscribing circle. Barely visible, as pairs of radial lines, are pairs of plasma vortex filaments which carry the electric current between the plasma focus electrodes.

Plasma is sometimes called the fourth state of matter—the other three being solid, liquid, and gas. When an electric current passes through a gas, the gas can become ionized: Electrons, which are ordinarily trapped into orbits around their atomic nucleus, like planets around the Sun, can be energetically kicked out of their orbits and roam freely. These free electrons make such ionized gases very good conductors of electricity. Furthermore, both the free electron and the stripped nucleus are electrically charged relative to a neutral atom, and therefore the ionized gas responds to electric and magnetic fields. Thus, as in magnetic fusion, ionized gases—plasmas—can be trapped into magnetic or even electrostatic bottles. In this way these plasmas can be insulated and heated to temperatures needed for nuclear fusion.

One method of producing such plasmas is the plasma pinch. In a general sense, a neon light is a plasma pinch. When an electric current is passed through neon gas which is trapped in a vacuum tube, it becomes a plasma and glows with a radiation output. The electric current passing through the neon plasma generates a magnetic field which traps and pinches the plasma.

The plasma focus is just like this, except that a much, much larger current is used.

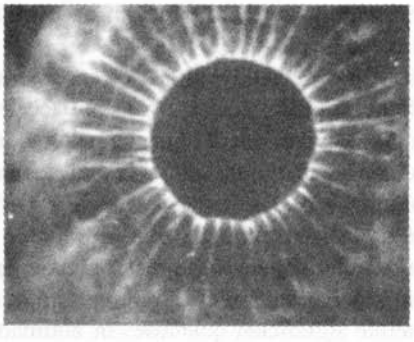
Like the other three states of matter, plasmas are, in general, macroscopically electrically neutral. Plasmas sometimes act like a solid, sometimes like an incompressible fluid, and sometimes like a compressible gas. In fact, it is better to think of solids, liquids, and gases as being three special varieties of plasma.

In general the electrons and nuclei which make up atoms and molecules become separated in a plasma—i.e. ionized. In other words, the atoms and molecules which comprise the relatively electromagnetically insulated elementary constituents of a solid, liquid, or gas are broken up.

With plasma, long-range electrodynamic forces predominate over the short-range chemical bonds and the molecular interactions that characterize solids, liquids, and gases. And it is this long-range electrodynamic interaction which is the chief manifestation of the plasma state.

While making the plasma far more complicated theoretically and experimentally, this long-range nature of the plasma interaction also makes the plasma potentially far stronger and more capable of supporting virtually infinitely greater energy densities.

a



b

a) The Dense Plasma Focus plasma annulus formed between the plasma focus electrodes.

b) The plasma annulus is seen here, forming pinch at the end of a Dense Plasma Focus electrode.