

Plasma



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Matter consists of atoms held together by electromagnetic forces. How tight these bonds are, determines which of the four states: solid, liquid, gas and plasma, matter exists as. Plasma is only found naturally in the corona and cores of stars and in bolts of lightning. There are three classic states of matter: solid, liquid, and gas; however, plasma is considered by some scientists to be the fourth state of matter. The plasma state is not related to blood plasma, the most common usage of the word; rather, the term has been used in physics since around the 1920s to represent an ionized gas. Space plasma physics became an important scientific discipline in the early 1950s with the discovery of the Van Allen radiation belts. Lightning is commonly seen as a form of plasma. Matter changes its state as it is exposed to different physical conditions. Ice is a solid with hydrogen (H₂) and oxygen (O) molecules arranged in regular patterns, but if the ice melts, the H₂O enters a new state: liquid water. As the water molecules are warmed, they separate further to form steam, which is a gas. In these classic states, the positive charge of each atomic nucleus equals the total charge of all the electrons orbiting around it so that the net charge is zero. Each entire atom is electrically neutral. When more heat is applied, the

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steam may be ionized: an electron will gain enough energy to escape its atom.

This atom is left one electron short and now has a net positive charge; called an ion. In a sufficiently heated gas, ionization happens many times, creating clouds of free electrons and ions; however, not all the atoms are necessarily ionized, and some may remain completely intact with no net charge. This ionized gas mixture, consisting of ions, electrons, and neutral atoms, is called plasma.

Plasma must have sufficient numbers of charged particles so that the gas, as a whole, exhibits a collective response to electric and magnetic fields. Although plasma includes electrons and ions and conducts electricity, it is macroscopically neutral. In measurable quantities, the number of electrons and ions are equal. The charged particles are affected by electric and magnetic fields applied to the plasma, and the motions of the particles in the plasma generate fields and electric currents from within. This complex set of interactions makes plasma a unique, fascinating, and complex state of matter.

Plasma is found in both ordinary and exotic places. When an electric current is passed through neon gas, it produces both plasma and light. Lightning is a massive electrical discharge in the atmosphere that creates a jagged column of plasma. Part of a comet's streaming tail is plasma from gas ionized by sunlight and other unknown processes. The Sun is a 1.5-million-kilometer ball of plasma, heated by nuclear fusion. Scientists study plasma for practical purposes. In an effort to harness fusion energy on Earth, physicists are studying devices that create and confine very hot plasmas in magnetic fields. In space, plasma processes are largely responsible for shielding Earth from cosmic radiation, and much of the Sun's influence on Earth occurs by energy transfer through the ionized layers of the upper atmosphere. Plasma and its properties will become very important in the energy field, in that if its energy was captured, it would be more powerful than current nuclear power.