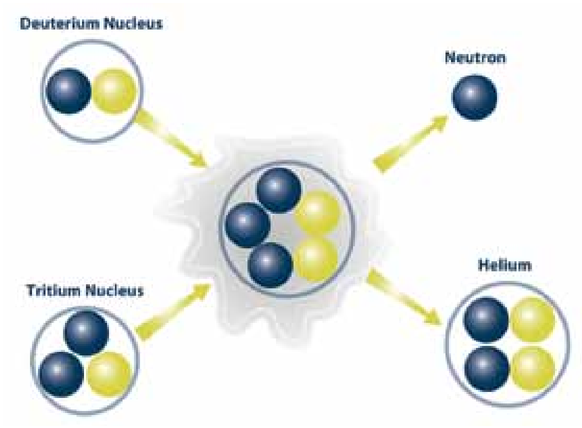

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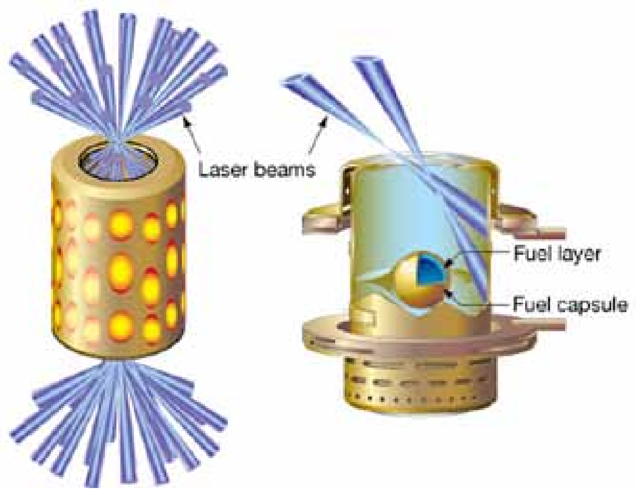
Deuterium and tritium fusing to become helium and a neutron: In one type of fusion reaction, two isotopes of hydrogen, deuterium and tritium, combine to form a larger helium nucleus and a neutron, releasing energy in the process. Conditions of at least 100 million degrees under sufficient pressure are required to produce fusion.

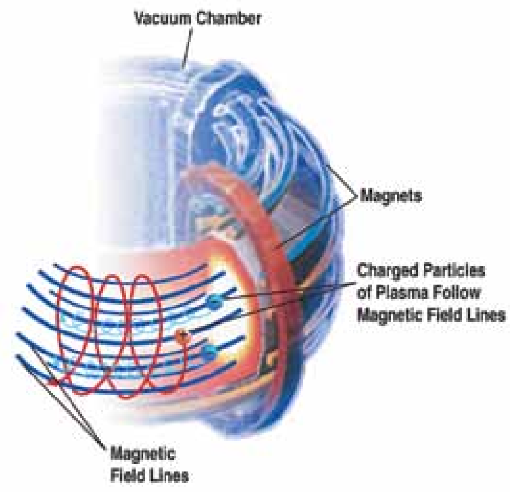
What Is Fusion?

As opposed to fission, the breaking apart of the heavier elements (uranium, plutonium, thorium, etc.), thermonuclear fusion is the bringing together of the lightest elements (hydrogen or helium isotopes for example). When two isotopes of hydrogen are fused, the process produces helium and a free neutron (together weighing less than the sum of the two original hydrogen isotopes), plus the release of energy in accordance with Einstein's famous discovery that small amounts of mass can be converted into large amounts of energy (in proportion to the speed of light squared, $E=mc^2$). These fusion reactants have energy densities millions of times greater than coal, oil, or natural gas, resulting in orders of magnitude less fuel required to generate comparable amounts of energy.

For example, the same amount of electricity can be generated from either 2 million tons of coal (21,000 rail-car loads), 1.3 million tons of oil (10 million barrels), 30 tons of uranium oxide (one rail-car load), or one-half ton of the hydrogen isotope of deuterium (one pickup-truck load). Since ocean water contains deuterium, a fuel for fusion, the energy available with fusion is relatively limitless.

Fusion is the process that powers in the Sun and the stars, as the light elements collide at high speeds and high densities. In both the Sun and in the laboratory, ultra-high temperatures (50-200 million degrees) strip the negatively charged electrons from the nuclei, resulting in a highly charged state of matter called a plasma, in which any material can be manipulated at its atomic level. To fuse atoms in the laboratory requires not only ultra-high temperatures, but also a means of containing and controlling the reaction, sustaining it at a steady rate over a long period of time.





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Inertial confinement and magnetic confinement. Left: This schematic of the National Ignition Facility shows its array of laser beams focussed on the tiny pellet of fusion fuel encapsulated in beryllium and carbide. The laser beams compress and heat the fuel pellet in a billionth of a second, so that the deuterium and tritium fuse before the pellet flies apart. The term "inertial" refers to the fact that the atoms must have enough inertia to resist flying apart before they combine.
Right: This diagram of a fusion tokamak shows the magnets, the magnetic field lines, and the charged particles of plasma that follow the magnetic field lines, spiralling around the tokamak. The magnetic fields "contain" the plasma.