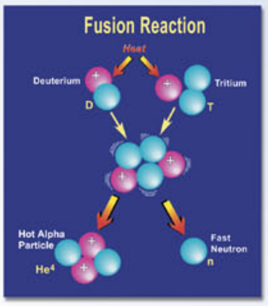
Fusion Energy Sciences

Excellent Science—Attractive Energy Resource

The Fusion Energy Sciences (FES) program leads the national research effort to advance plasma science, fusion science, and fusion technology—the knowledge base needed for an economically and environmentally attractive fusion energy source.

Fusion Reaction: Fusion, the energy source of the sun and other stars, is a reaction process that converts matter into energy. Fusion occurs in plasmas when two nuclei of hydrogen, such as deuterium or tritium, are combined (fused) together under enormous temperature and pressure to form a single nucleus of helium. During the fusion process, some of the matter involved in the reaction is converted directly into a much larger amount of energy. For example, the amount of deuterium in one gallon of sea water would yield the energy equivalent of 300 gallons of gasoline.



"I think fusion is going to be an important energy technology for the future and we need to be working toward that end."

John Marburger, Presidential Science Advisor
National Public Radio, January 18, 2002

Historic Accomplishments

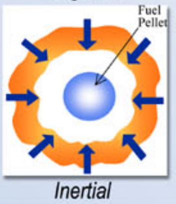
- In 1978, scientists at the Princeton Plasma Physics Laboratory achieved, for the first time, ion temperatures in the Princeton Large Torus in excess of 58 million degrees celsius, the minimum temperature required for a self-sustaining reaction.
- In 1994, the Tokamak Fusion Test Reactor facility at the Princeton Plasma Physics Laboratory (PPPL) produced a short pulse of 10 million watts of fusion power, 100 million times more than the power produced in fusion research facilities 20 years earlier.

Recent Scientific Achievements

- **Achievement of High-Performance Fusion Plasmas**—Guided by theory and simulations, scientists at General Atomics' DIII-D National Fusion Facility demonstrated high performance, steady-state operation of the DIII-D tokamak by using high-power microwaves for external control of currents and plasma pressure. Calculations based on these results increase confidence in future burning plasma experiments such as ITER.
- **Computer Simulation of New Phenomena in Large Tokamaks**—Using the IBM SP3 supercomputer at the National Energy Research Supercomputer Center to simulate experimental phenomena observed in European and Japanese tokamaks, the experimental results can be explained by "magnetic reconnection," a process closely related to similar events that occur in solar flares.

Magnetic and Inertial Confinement:
The two principal approaches for confining fusion fuel on earth are magnetic and inertial. Magnetic fusion relies on magnetic forces to confine the charged particles of the hot plasma fuel for sustained periods of fusion energy production. Inertial fusion relies on intense lasers or particle beams to rapidly compress a pellet of fuel to the point where fusion occurs, yielding a burst of energy that would be repeated to produce sustained energy production.

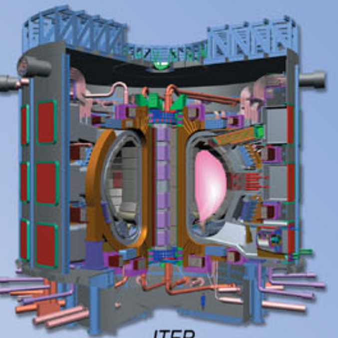
Magnetic



Inertial

Major User Facilities

The Future: ITER. The U.S. is engaging in negotiations with international partners aimed at constructing the world's first sustained burning plasma experiment, capable of producing 500 million watts of fusion power for periods of 5 minutes or more. www.ofes.fusion.doe.gov/iter.html



ITER

DIII-D, General Atomics, is the largest magnetic fusion research facility in the United States, with plasmas at close to fusion reactor temperatures. web.gat.com/diii-d/

DIII-D Tokamak

NSTX, Princeton Plasma Physics Laboratory, is an innovative magnetic fusion device that was constructed by the Princeton Plasma Physics Laboratory in collaboration with the Oak Ridge National Laboratory, Columbia University, and the University of Washington at Seattle. www.pppl.gov/projects/pages/nstx.html

NSTX

Alcator C-Mod, Massachusetts Institute of Technology, is a unique, compact-tokamak facility that uses intense magnetic fields to confine high-temperature, high-density plasmas in a small volume. www.psfc.mit.edu/cmod/

Alcator C-Mod

Science Workforce Development

FES Grant Information:
www.sc.doe.gov/grants.html

Undergraduate Fellowship Program in Plasma Physics and Fusion Energy Sciences:
science-education.pppl.gov/Nuf/index.html

Fusion Energy Sciences Graduate Fellowship Program:
www.orau.gov/orise/edu/DOE/gi-gFES.htm

Fusion Energy Sciences Postdoctoral Research Program:
www.orau.gov/orise/edu/postgrad/feupgr.htm

Office of Science
U.S. DEPARTMENT OF ENERGY

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