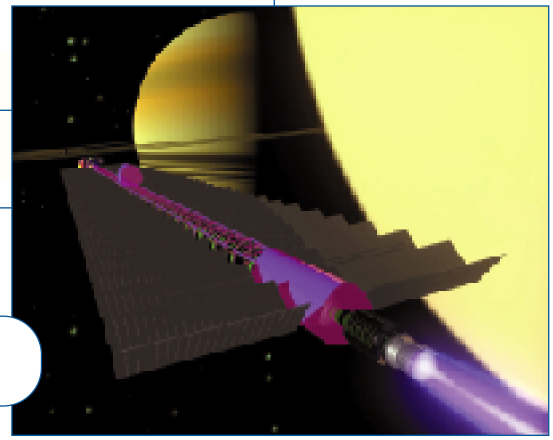

Fusion Propulsion

Fusion is an important part of our everyday life on Earth, and may someday be an important part of our life in space. It's the basic reaction that provides the warmth and light we receive from the Sun. NASA's Marshall Space Flight Center in Huntsville, Ala., is investigating fusion as a possible energy source for journeys to faraway planets.

Fusion—the process of combining lightweight atoms to produce slightly heavier ones—releases an extremely high amount of energy. In a fusion propulsion system, the process is initiated by heating hydrogen atoms to extremely high temperatures. Hydrogen or some other lightweight element would fuse together in the form of plasma, or electrically charged gas. Magnetic nozzles could direct the charged particles to achieve propulsion as the plasma is exhausted from the engine.

The enormous energy generated by fusion makes it a viable candidate for interplanetary travel. A fusion drive's specific impulse—the rocket science equivalent of miles per gallon for a car—rates about 300 times higher than the best chemical rocket engines. About 450 seconds is a typical chemical rocket engine's specific impulse—the number of seconds the engine can produce one pound of thrust from one pound of fuel. Specific impulse of a fusion rocket is estimated at 130,000 seconds—an efficiency rating equal to a car getting 7,000 miles per gallon (almost 3,000 kilometers per liter)!

A rocket propulsion system's efficiency increases as its gases get hotter. In a fusion drive, the gas would be heated to temperatures comparable to the inside of the Sun. As the gas exits the nozzle, its temperature would approach 100 million degrees Celsius (180 million degrees Fahrenheit), more than 25,000 times hotter than gases expelled from the Space Shuttle Main Engines.

A fusion drive is a technically feasible alternative for interplanetary space travel within 25 years. Fusion is one of the most promising in-space propulsion technologies for rapid travel throughout our solar system. It could power a fully reusable, interplanetary spacecraft that could make human travel to other planets routine. Round trips from Earth to Jupiter could take just a couple of years.

Fusion offers several attractive safety features. The fusion process is not a chain reaction so it can't result in a "meltdown" accident. And the products of a fusion reaction are not radioactive, so no long-term wastes would be generated.

Significant technical challenges must be overcome to make fusion propulsion possible. Producing and confining hot, dense plasma and managing the engine's extreme heat without prohibitively heavy cooling systems are among the hurdles.

NASA has several experiments under way to investigate fusion propulsion. At the Marshall Center, engineers and technicians have built a unique Gas Dynamic Mirror fusion propulsion experiment to learn more about how to stabilize hot plasma by manipulating magnetic fields that confine the hot gas. A long, slender solenoid—a current-carrying coil of wire that acts like a magnet—surrounds a vacuum chamber that contains the plasma. A wide range of tests is anticipated with different configurations that involve lengthening the experiment device and rearranging the magnets. The Marshall Center's technology development activity in the area of fusion propulsion also includes magnetized target fusion and inertial electrostatic confinement experiments.

NASA's academic and government partners in the fusion propulsion technology work include the University of Michigan at Ann Arbor; Ohio State University in Columbus; Princeton University in Princeton, N.J.; University of Illinois in Champaign; and the Los Alamos National Laboratory in Los Alamos, N.M.

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