NASA Technology Summary

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

Propulsion Research Center

Antimatter Propulsion

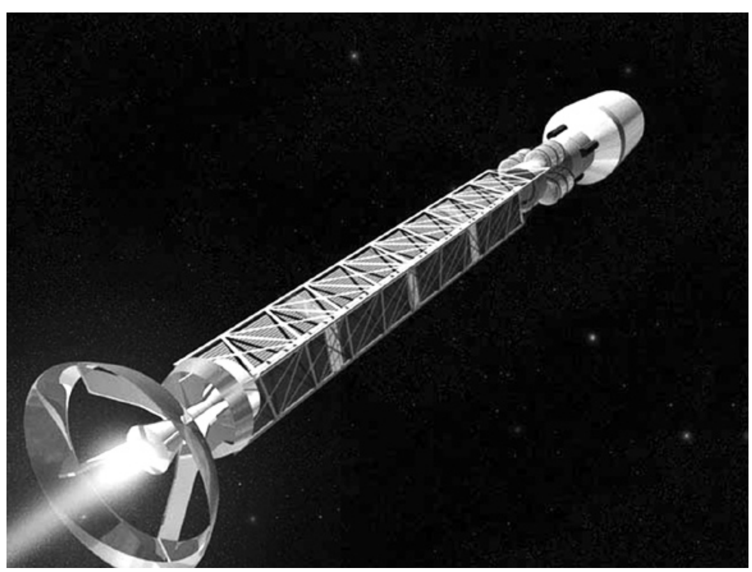
Traveling to the stars will require ultra high-energy propulsion systems. The mutual annihilation of antimatter and matter packs the highest energy density of any reaction known in physics—perhaps just the energy source needed to trek to the stars.

Antimatter propulsion is a staple of science fiction, and technology development activities now under way in the Propulsion Research Center at NASA's Marshall Space Flight Center in Huntsville, Ala., could loft an antimatter-powered starship into the realm of reality before the close of the 21st century.

Antimatter is the mirror image of normal matter we see all around us. It's composed of subatomic particles that mirror the mass of their ordinary matter counterparts—electrons, protons and neutrons—but with an opposite charge and magnetic properties. If the burst of energy produced when particle meets antiparticle could be efficiently harnessed, a space propulsion vehicle could produce a specific impulse—the performance of a propellant or total impulse transferred to a spacecraft per mass—thousands of times greater than the energy produced by a Space Shuttle Main Engine. Science missions beyond the outer planets—among the stars themselves—could be within reach.

The specific energy density released from proton-antiproton annihilation is 10-billion-times greater than oxygen-hydrogen combustion and at least 1,000-times more energetic than fission or fusion. In other words, one gram of antihydrogen—the mirror image of a hydrogen atom—combined with an equal amount of normal hydrogen provides the same amount of energy as 23 Space Shuttle External Tanks.

The challenge facing researchers, however, is because of the rarity of antimatter in the universe, it has to be created in a laboratory environment. For almost half-a-century, antiparticles have been created in laboratories with a large (four-mile circumferential ring) particle accelerator. Only two U.S. laboratories generate significant antiprotons—Brookhaven National Laboratory in Upton, N.Y., and Fermi National Accelerator Laboratory in Batavia, Ill. The laboratories produce antimatter by accelerating particles, such as protons, near the speed of light and ramming them into heavy-nuclei



targets. The current worldwide, annual production of antimatter is only two-billionths of a gram. However, microgram quantities are feasible within 15 years with several successful upgrades to current facilities.

The energy from the matter-antimatter reaction could be used to heat or accelerate a working fluid to propel a spacecraft. Researchers at the Marshall Center are studying the feasibility of hybrid antimatter propulsion concepts that could use microgram quantities of antimatter as a “spark igniter” for a fission or fusion reaction.

Dramatic improvements in the production, storage and use of antimatter will be required to make it a viable propulsion alternative. Researchers at the Marshall Center’s Propulsion Research Center are focusing efforts on storage of antimatter. Marshall’s High-Performance Antiproton Trap, called HiPAT, is the largest portable trap of its kind in the world, built to hold up to 10^{12} antiprotons for several weeks. The experimental trap consists of an ultra-high-vacuum electromagnetic container that traps antiprotons and prevents them from destroying themselves by hitting the container walls or other gas particles. The trap can be transported to a laboratory that produces antiprotons and filled with particles. It then can be taken to labs or universities for experiments that could help develop technologies for anti-matter.

The Marshall Center is developing revolutionary space transportation and propulsion system technologies that promise a new age of space exploration—key to NASA’s exploration mission goals in the Vision for Space Exploration. The Vision calls for Space Shuttles to return to safe flight to complete the International Space Station, and more ambitious human and robotic exploration of the Solar System. These innovative technologies will dramatically shorten trip times, increase safety and reliability, and reduce the cost of space transportation.

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