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Space Propulsion Methods

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In an effort to better explore the universe, a number of different propulsion methods have been proposed to permit further exploration of the solar system. Three different groups of propulsion methods will be examined. The first are methods that exist today which could immediately be used to power spacecraft. The next group are emergent propulsion methods based on cutting edge technology, and the third are potential future technologies that have the potential to greatly increase the scope of human exploration.

In the first group, one common propulsion method that organizations like NASA have been using for a while to power their spacecrafts is an ion drive. In an ion drive, typically atoms of a propellant are bombarded with high energy electrons that displace additional electrons, creating positively charged ions. The thruster contains a negatively charged electrode which attracts the ions, accelerating them in a beam outside of the drive and generating thrust [1]. Xenon is typically used as the propellant for these drives, because it is easily ionized, is chemically inert, making it very safe to transport, and can be stored in large quantities while taking up relatively little space [1]. The NEXT xenon thruster developed by NASA has a "fuel efficiency of 10-12 times greater than a chemical thruster", allowing spacecraft to travel much further using the same amount of fuel. The engine generates much less thrust, however, than a combustion system and requires an uptime of nearly 10,000 hours in order to generate high enough velocity to reasonably reach the asteroid belt and other objects in the solar system [1]. Another existing method of propulsion that has garnered interest in the scientific community is a solar sail. A large sail is used to catch photons of light, harnessing the momentum of the photons and accelerating the sail [2]. Later this year, the LightSail project, endorsed by Bill Nye, will be launching its 344 square feet sail into space. While this propulsion method has the advantage of requiring no fuel, it is reliant on a source of light to power the sail, which becomes impractical as the sail moves away from the Sun.

The second group of propulsion methods includes less available technologies that may or may not ever be widely adopted to power spacecrafts. One such method is an antimatter drive, which harnesses antimatter as a fuel source. Antimatter is an incredibly efficient fuel source, requiring only tens of milligrams to propel a spacecraft to Mars, compared to the tons required by a chemical based propulsion system [3]. Antimatter is made up of antiparticles, particles with equivalent mass but opposite charge to those of typical matter [4]. An electron's antiparticle is called a positron. When a particle and its respective antiparticle collide, they annihilate, efficiently releasing energy that can be captured. In 2006, the NASA Institute for Advanced Concepts (NIAC) recruited a team to design the concept for an antimatter powered spacecraft. While an antimatter engine would be very efficient, it is also very difficult and ultimately costly to produce sufficient antimatter fuel. Dr. Gerald Smith of Positronics Research, in partnership with NASA, estimated that "to produce the 10 milligrams of positrons needed for a human Mars mission is about 250 million dollars using technology that is currently under development" [3]. Additionally, the only way to produce antimatter on Earth is to use particle accelerators, which are typically used for research purposes, but could be dedicated to producing antimatter [3]. Besides antimatter, another peculiar propulsion method that could potentially power future spacecrafts is the EmDrive. An EmDrive works by pumping electromagnetic radiation such as microwaves in a conical chamber, moving the drive forward [5]. While typically propulsion methods require a a mass to be emitted to generate thrust, such as the xenon particles in an ion drive, there is no consumed propellant in an EmDrive. This technology is still being heavily scrutinized, however, last year NASA's Advanced Propulsion Physics Research Labratory, nicknamed Eagleworks, published unexpected experimental evidence supporting this propulsion method. The fact that it does not emit any propellant contradicts Newton's Third Law, as there is no force acting opposite the direction of acceleration, however, in Eagleworks experiments, the EmDrive generated "1.2 millinewtons per kilowatt of energy" when run in a near vacuum [5]. While there are quantum mechanics based arguments as to how this machine generates thrust, such as foundations in "pilot wave theory", there is no consensus on how this machine works and scientists may have to try it in space to determine whether it does actually work as evidenced in recent experiments [6].

The third group of propulsion methods include advanced technologies that while based in science, are unlikely to been seen in spacecraft for a long time. The primary example of such a propulsion method is a warp drive, made popular by science fiction and rooted in the ability of space to be warped. Richard Obousy, president of Icarus Interstellar, explains that while "Everything within space is restricted by the speed of light", "the fabric of space, is not limited by the speed of light" [7]. Space is constantly expanding and given its ability to expand and contract, a warp drive would contract the space in front of a spacecraft and expand the space behind it. While fascinating, the technology is impractical, with one study estimating the amount of energy required for such a drive to be about the "mass-energy of the planet Jupiter" [7] and this technology is definitely very far away.

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