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The Helical Engine

"Proxima Centauri, one of three stars in the Alpha Centauri system, is the nearest star to our sun. It's 4.22 light-years away" (Byrd). This is a vast distance for the human civilization as interstellar pioneers. In terms of modern day space propulsion technology, an interesting realization of the favored rocket-propulsion systems highlights their impractical use for this type of space traveling. On the simplest level, chemical rocket engines take advantage of Newton's third law by producing thrust, a force along the direction of motion, by burning fuel and expelling large amounts of energy in the direction opposite to the motion of the rocket. Consider the New Horizons spacecraft, one of the most recent spacecraft that traveled nearly 10 years from Earth to Pluto in the time period from 2006-2015. "NASA's New Horizons spacecraft travels at 36,373 miles per hour… If New Horizons were aimed toward the Alpha Centauri system, which it isn't, it would take this spacecraft about 78,000 years to get there" (Byrd). A mission that takes 78,000 years is not a viable option. The age of conventional rockets has reached its limitation as human civilization looks onward for new and prospective methods of interstellar travel.

Moreover, such an innovative idea has just been proposed by Dr. David M. Burns, an engineer for the NASA Marshall Space Flight Center. In Dr. Burns' topic proposal for a new type of propulsion system to be used in space, the Helical Engine, he outlines the physics concepts behind the mechanics of the engine and suggests aspects of the proposed concept that can be improved in the future. However, before explaining the overall concept of the engine, understanding the fundamental physics principles that permit the engine's capability proves to be important.

Furthermore, the helical engine concept relies on the principles of Modern Physics, specifically Special Relativity and relativistic momentum. Relativistic momentum is defined as $p = \gamma mv$, where γ is the Lorentz factor and contributes a proportional increase to the classical momentum when the absolute velocity of an object reaches a significant percentage of the speed of light. The fundamental conclusion of Special Relativity is that any object with mass cannot surpass the speed of light. Equally as important, the relativistic kinetic energy of the hypothetical object also includes the γ factor, showing a comparable growth as the relativistic speed of the object reaches near the speed of light. Additionally, there are two main forces referenced in the Helical Engine concept, a perpendicular force equal to γma and a parallel force equal to $\gamma^3 ma$. These forces are important in evaluating the loss in relativistic momentum/energy in the opposed directions of motion.

In fact, the direct implementation of these concepts pertains to the central part of the engine, a helical-shaped particle accelerator. In Dr. Burns' proposal of the new concept, he explains how particles that are accelerated through the circular and coiled direction of motion will produce a momentum component that is parallel to the thrust vector and desired motion of the spacecraft. The particle accelerator itself utilizes "electric and magnetic fields to accelerate and guide ions inside a closed and sealed tubular vacuum line" (Burns). Specifically, the helical particle accelerator has an inner and outer core, where the particles or ions are accelerated and decelerated respectively. The key concept of the engine is to increase the absolute velocity of the ions towards the top of the engine and decrease the absolute velocity of the ions as they travel back towards the bottom of the engine.

According to Special Relativity, these ions will experience changes in mass as they are accelerated and decelerated, for the overall energy of the ions increases as their speed is increased indefinitely. Therefore, “the relativistic mass is imagined to increase with increasing speed” (Serway), for which causes the positive change in momentum in the direction the engine system will travel. These effects on the mass of the ions are obtained through changing the rotational velocity around the axis parallel to the engine’s motion while also increasing the radius of rotation as the ions accelerate and decreasing the radius of rotation as the ions decelerate. The desired goal is to have the net change in momentum of the ions in the helical particle accelerator create a thrust force in the direction perpendicular to the ions rotational velocity, thus allowing the overall engine-system to accelerate.

In fact, comparing the helical engine to conventional chemical rockets in the scenario of traveling to Proxima Centauri highlights the technological advantages amidst the disadvantages. Firstly, since the helical engine system can essentially accelerate so long as it has power, a spacecraft with this engine accelerated to ten percent the speed of light would take just under 10 years to reach the Proxima Centauri star. However, a spacecraft traveling this fast is only feasible if the helical engine has an optimum, efficient power supply. The biggest drawback to the helical engine proposed by Dr. Burns is the enormous amount of energy, on the order of 165 megawatts, required to produce just one newton of thrust. An engine that runs on this much power input is not quite feasible; however, one of the main improvements Dr. Burns highlights in his design proposal is the addition of a harvesting mechanism during the deceleration phase of the engine. Due to the deceleration of the ions in the helical engine producing energy equal to the amount put in, an immense reduction in the required power input is possible if the energy put in to the helical engine can be effectively recaptured. On the other hand, chemical rockets are designed to burn fuel/energy in order to accelerate the rocket, so there is no concept of reusing this energy once the rocket reaches its target speed. Perfecting the accumulation of energy produced by decelerating ions in the helical engine is one of the biggest engineering obstacles of the engine's design; although, it will be key to successful implementation of the helical engine in future interstellar spacecraft.

In the case that the helical engine is seen to fruition, there are certainly societal impacts that will follow. The human species currently dwells as an earth-bound civilization, and such a technology like the helical engine would bring forth the new opportunity to extend humanity's outreach beyond our own solar system. The idea of colonizing a distant exoplanet has been a mere fantasy in the last century, but the technology of this engine would allow humans to make this a reality. In the example of traveling to Proxima Centauri for "a starship with a dry mass of one thousand tons that can cruise at .10c… the energy costs alone would amount to 12.5 trillion dollars" (Kanas). With this enormous cost, a new focus on colonization would be established for the human population as meeting the requirements for resources, energy, etc. needed for traveling through interstellar space are carefully sought out. Additionally, the helical engine technology would undoubtedly permit humans to completely survey the solar system, dramatically increasing the knowledge of planetary attributes or their specific origins to further understand the universe as a whole. With the direct implementation of this engine technology in future spacecraft, achieving new, astronomical success in our solar system and beyond is certain.

Obviously the physics behind Dr. David Burns's helical engine is due for field-testing and physical modeling so that the viability of the engine can be determined. As shown above, the theoretical modeling of the helical engine design has immense advantages in potential efficiency and capabilities of producing thrust over conventional rockets. Optimizing the energy and power input required for the helical engine will allow for building the most effective interstellar spacecraft. With these advantages in mind, the concept of the helical engine has tremendous room for improvement in order to employ the theoretical engine into a real spacecraft in the near future. After all, the helical engine technology would be used to travel to nearby stars and exoplanets, becoming the greatest achievement in the history of human exploration.

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