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MUON CATALYZED FUSION: A PLACE IN SPACE?

Abstract

Nuclear power, in the form of nuclear-thermal or nuclear-electric is poised to be the next big leap in rocket technology. Thus far, most research has focused on fission reactors, but fusion reactors are lurking just over the horizon. While the various terrestrial nuclear fusion projects have made great strides in recent years, break-even power generation and commercial viability are still several years away. The miniaturization required for space applications will require several additional years of research after reaching commercial viability. Alternatively, we suggest that spacecraft powered by muon-catalyzed fusion may be feasible in the near term, and the special properties of muon catalyzed fusion make it more feasible in space than on Earth. The purpose of this talk is to evaluate the potential of muon-catalyzed fusion for space applications.

To fuse two atoms together, we need to bring the two nuclei extremely close to each other, within the electron clouds of the two atoms. At this short distance, the Coulomb forces are extremely large. In order to overcome that barrier, the atoms need to have large initial kinetic energy. The NIF project uses an array of lasers to compress the hydrogen together, while the ITER project uses high temperatures and magnetic confinement; both involving large complex machinery. A muon is similar to electron, only much heavier. When introduced into a hydrogen gas, a muon will displace an electron in an atom, but orbit much closer to the nucleus, effectively screening the charge of the nucleus to a much smaller radius. A second nucleus can than approach to a much smaller distance without experiencing the Coulomb barrier. Fusion can then proceed at a much lower temperature.

Muon catalyzed fusion has been previously studied as a source of terrestrial power and was found to be economically unviable, due to the low number of background muons and the high cost of producing artificial muons. Background muons are produced by cosmic rays when a cosmic ray particle collides with particles in the atmosphere, producing a shower of pions. The negatively charged pions then decay preferentially into muons, and the muons eventually decay into electrons in 2.2 microseconds. Due to the short muon lifetime, only the highest energy muons are present at the Earth's surface, however, we place the reaction chamber in space, with a thick wall for the impinging cosmic rays, we can access the entire spectrum of muons to catalyze fusion reactions.