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SUB-SCALE DEMONSTRATION OF AN AXIAL PULSED MAGNETIC NOZZLE FOR NUCLEAR PROPULSION SYSTEMS

Abstract

Robotic missions and crewed missions to interplanetary destinations are challenging because of long trip times. For example, with current technology, robotic rendezvous missions to an outer planet (Jupiter, Saturn) will take 5-20 years; crewed Mars missions will take 2-3 years. During this time microgravity and cosmic rays will significantly damage the physical and mental health of the astronauts; long missions to the outer planets increase the chance something could go wrong. Therefore, shorter mission times increase the safety and reliability of missions. It was known since the 1960 that a fusion propulsion system could accomplish these missions much faster due to their inherent high specific power (= 1-10 kW/kg): 1-4 years for the outer planet mission, 1-3 months for crewed mars. However, fusion propulsion systems are hampered by the high-temperature of the exhaust, which melts any metal used to create the nozzle. A magnetic nozzle, a device that uses high-strength magnetic fields to direct exhaust instead of metal walls, must be used instead. However, in the past such systems can be inefficient. Most magnetic nozzles use a solenoidal design, but recent work suggests an axial design is more efficient. However, axial designs have not been as widely tested in the laboratory as solenoidal designs. We propose undertaking the first test of a subscale version of an axial nozzle; our nozzle will be 60 mm in radius by 60 mm in length with 40 number of struts, each having a current of 600 A. We will generate our plasma in a similar manner to the solenoidal experiments with a 1064 nm 0.5 J infrared laser that will ablate a carbon graphite target. We will measure thrust with both a direct-measurement thrust stand and series of charge collectors and compare results against the two methods and simulation. We expect it to perform as good or better than current solenoidal designs; and we expect these data to increase the feasibility of axial nozzles and allow humanity to explore the solar system.