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The Plasmoid Thruster Experiment (PTX)

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A plasmoid is a compact plasma structure with an integral magnetic field. They have been studied extensively in controlled fusion research and are categorized according to the relative strength of the poloidal and toroidal magnetic field (B_p and B_t , respectively). An object with $B_p/B_t \gg 1$ is classified as a Field Reverse Configuration (FRC); if $B_p \approx B_t$, it is called a Spheromak.

There are a number of possible advantages to using accelerated plasmoids for in-space propulsion. A thruster based on this concept would operate by repetitively producing plasmoids and ejecting them from the device at high velocity. The plasmoid is formed inside of a single turn conical theta-pinch coil; as this process is inductive, there are no life-limiting electrodes. Similar experiments have yielded plasmoid velocities of at least 50 km/s (1), and calculations indicate that velocities in excess of 100 km/s are possible. A thruster based on this concept would be capable of producing an I_{sp} in the range of 5,000 – 10,000 s, with thrust densities of order 10^5 N/m². The current experiment is designed to produce jet powers in the range of 5-10 kW, although the concept should be scalable to higher power.

The purpose of this experiment is to determine the feasibility of this plasma propulsion concept. To accomplish this, it will be necessary to determine: a.) specific impulse and thrust, b.) efficiency and mass utilization, c.) which type of plasmoid (FRC-like or Spheromak-like) gives the best performance, and d.) the characteristics required of actual thruster components (i.e., switch and capacitor technology). The plasmoid mass and velocity will be measured with a variety of diagnostics, including internal and external B-dot probes, flux loops, Langmuir probes, high-speed cameras, and an interferometer. Simulations of the plasmoid thruster using MOQUI, a time dependent MHD code, will be carried out concurrently with experimental testing. The PTX device is currently undergoing initial testing and preliminary experimental results are presented.

1.) "Generation of poloidally rotating spheromaks by the conical theta pinch", K. Kawai, Z.A. Pietrzyk, and H.T. Hunter, *Phys. Fluids* 30(8), August 1987, pgs. 2561-2568