# Propagating Magnetic Wave Plasmoid Accelerator

**Jedediah M. Smith, Matthew J. Bartone, Andrew J. Greenlee, John T. Slough**

*University of Washington; Aeronautics and Astronautics Department; Plasma Dynamics Lab; Seattle, WA 98195*

**Abstract**

A high-velocity plasma accelerator utilizing a Propagating Magnet Wave (PMW) has been designed and constructed that is directly applicable to space propulsion as well as to new innovative high energy density approaches towards fusion. The PMW plasmoid accelerator also has possible applications as a fueler for future fusion reactors such as the international fusion reactor, ITER, as well as current tokamak experiments for adding rotational momentum and velocity shear for enhanced stability and transport control.

The natural application for the PMW accelerator is for high power electric propulsion in space. For this purpose the PMW is employed as a pulsed thruster that operates naturally at both high power and efficiency with no need for electrodes or grids. Operational parameters can be varied over a wide range in both exhaust velocity and propellant mass. To efficiently accelerate plasmoids to high velocities an acceleration method other than the simple tapered coil must be employed. In these experiments, the rapid acceleration of a compact plasmoid is realized through the application of an externally applied propagating magnetic field. Here, the large axial JxB force is generated from the induced azimuthal current inside the plasmoid and the radial component of the external, axially propagating magnetic field. This accelerating force is sustained as long as the plasmoid remains in phase with the wave field. Exit velocities greater than 200 km/sec for plasmoid masses on the order of 0.1 mg are anticipated from the device that is currently being tested, and the results from the initial experiments will be presented.

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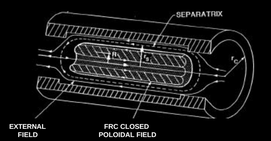
## Field Reversed Configuration Geometry

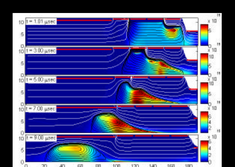


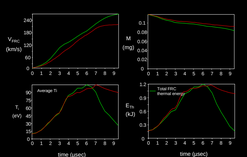

Equilibrium Relations:

$$P_0 = n_0 kT = \frac{B_{ext}^2}{2\mu_0}$$ Radial Pressure Balance

$$\langle \beta \rangle = \int_0^{r_s} \frac{2\mu_0 P}{B^2} dr = 1 - \frac{1}{2} x_s^2$$ Axial Pressure Balance

$$B_{ext} = \frac{B_{vac}}{\left(1 - x_s^2\right)}$$ Flux conservation





Predicted results from MHD (Moqui) modeling

## Summary

Arc gun test shot (view down tube)

**High Velocity Plasma Accelerator**

**Possible applications:**

- High power electric propulsion in space
- New approach to high density fusion
- Fueling Source for ITER and Tokamaks

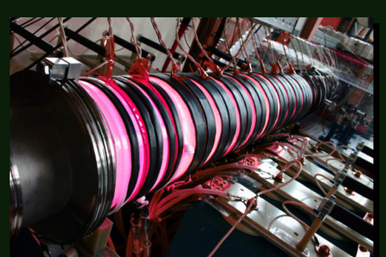
**Combining plasmoid creation with efficient pulsed magnetic wave acceleration**

**No electrodes or grids to corrode**

**Can be operated over a wide range of exhaust velocities and propellant masses**

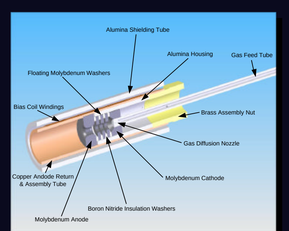
**Exit velocities >200km/s for plasmoid masses of ~0.1mg are anticipated**

**With a 10kHz repetition rate an output of 30MW could be achieved**

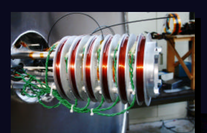


Plasma shot

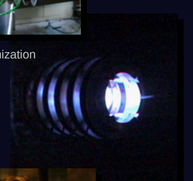
## Construction




Arc gun



Helicon pre-ionization



### Plasma Creation

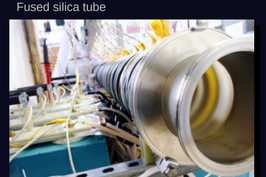
**Arc gun (8eV, $10^{20}$ part/$m^3$)**

**Helicon pre-ionization (10eV, $10^{20}$ part/$m^3$)**

**Second half cycle ionization**

Arc gun

Fused silica tube



### Vacuum System

**Fused silica tube (Rotosil)**

**One meter diameter stainless steel dump chamber**

**1200 1/s magnetic-levitation turbo pump**

**Base pressure in the low $10^{-8}$ torr**

Digitizer rack

### Control and Data Acquisition

**LabView control and automation programming**

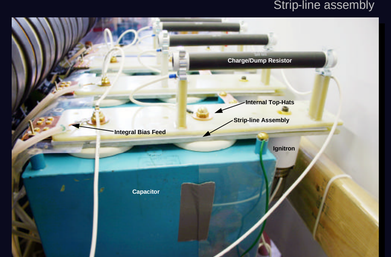
**Fiber Ethernet isolated LabJack for analog and logic control of high voltage**

**CAMAC DSP transient digitizers (8bit, 10MHz)**

**Timing and control via fiber out of CAMAC Jorway 221 and 222 modules**

LabView experiment control software

Strip-line assembly




### Plasma Acceleration

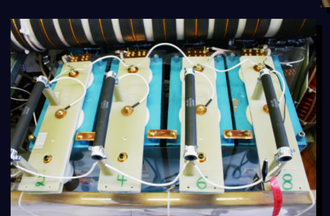
**Individually controlled high speed coils (eight total)**

**Low inductance strip-line feed from caps to coils**

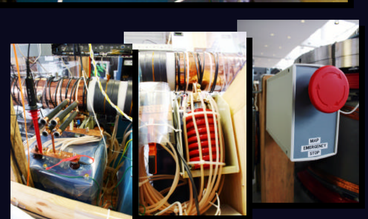
**Integral bias field**

**Ignitron switching 25kV, 100kA**

**Copper flux shaper on drift and diagnostic region**



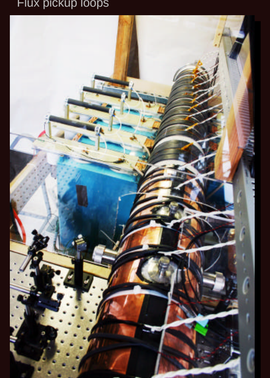
25kV, 14 uF capacitors



Integral bias supply/emergency stop button

## Diagnostics

Flux pickup loops



### Integral Magnetic Probes

**Arranged in sets consisting of:**

- One total flux sensing loop
- One hair-pin flux density loop

### Refurbished Spex Spectrometer

**16 channel PMT**

**0.28 Å resolution**

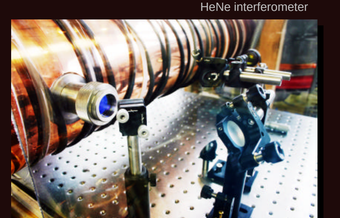
**Wavelengths from soft UV to NIR**

### Triple Tip Langmuir Probe

**Six foot length for axial studies**

### End-On Optical Access

HeNe interferometer



### Double Pass HeNe Mach-Zender

**40MHz Bragg cell**

**High stability from damped, isolated single optics table**