Magnetized Beam Plasma Propulsion

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INTRODUCTION

Advanced electric propulsion systems such as that proposed for the Jupiter Icy Moon Orbit (JIMO) are becoming increasingly massive due to the need to carry large power units to obtain sufficient thrust from plasma thrusters/engines.

The scenario of a large nuclear power system for each new mission also represents a very costly approach.

Magnetized Beamed Plasma Propulsion (MagBeam) provides a viable solution to these two critical problems.

MagBeam also has the critical feature that plasma/magnetic field effects allow self-focusing of the beam plasma so that energy divergence of the beamed energy that plagues other beamed systems can be mitigated.

SYSTEM REQUIREMENTS

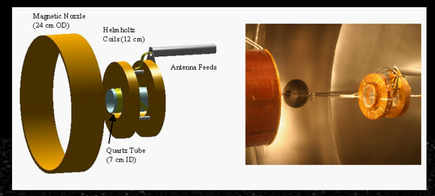
(1) Large power unit is placed in orbit around key destination such as at Mars and at Geosynchronous orbit around the Earth - one system produces acceleration to the planet, and one system provides braking as the payload approaches the planet.

(2) High power helicon plasma source to generate the beam plasma and focusing magnetic field. The prototype at UW is setting records for beamed plasma generation.

(3) Particle Deflector on the payload, which is nothing more than an extended magnetic field, possibly provided by a mini-magnetosphere (M2P2) or Plasma Magnet system.

Because the payload is separated from the power system, the mass of the payload is very much smaller and subject to very much larger acceleration than typical electric propulsion systems.

MagBeam can be used repeatedly to be power multiple orbital transfers of desired payload around a planet to the various planets.

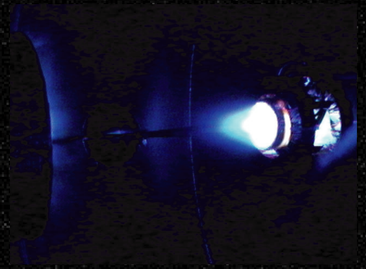


High Power Helicon (HPH)

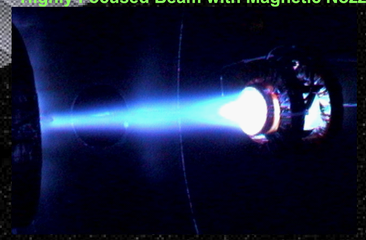
New plasma technology that operates in a very important regime in which the thermal pressure of the plasma is less than the magnet field so that the magnetic field can guide the plasma but where the plasma has a great dynamic pressure (i.e. directed energy) so that the plasma drags the magnetic field with the beam to provide self-confinement of the plasma beam.

HPH uses large amplitude whistlers (i.e. EM waves below the electron cyclotron frequency) to generate the plasma stream at energies of several tens of eV (10-30 km/s depending on propellant choice). The whistlers are driven by solid state switching circuits at tens of kW powers. DC coil magnets facilitate the generation of the whistlers and extra magnets provide focusing of the plasma.

Operation of HPH without any Magnetic Nozzle Magnets



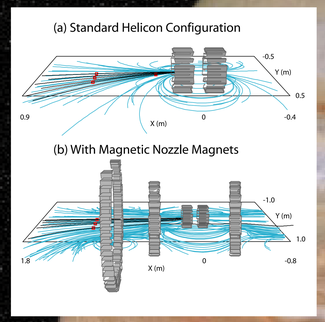
Highly Focused Beam with Magnetic Nozzle

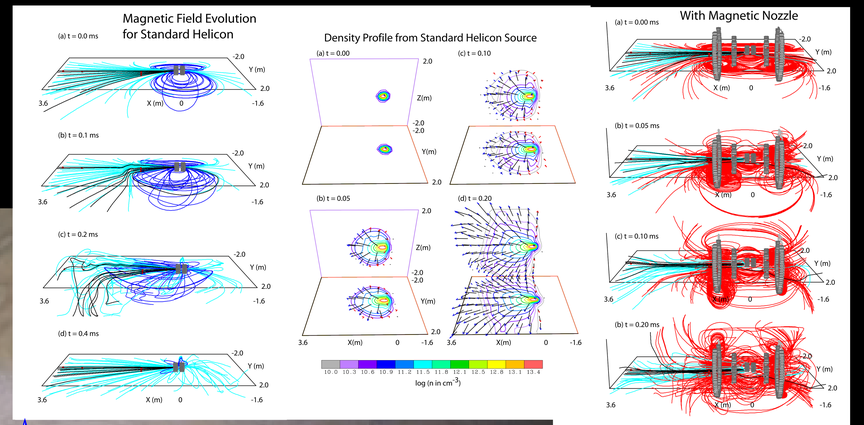


Computer Simulations

Are used to demonstrate the ability of the system to produce focused plasma beam, and the self-focusing provided by the deflector system.

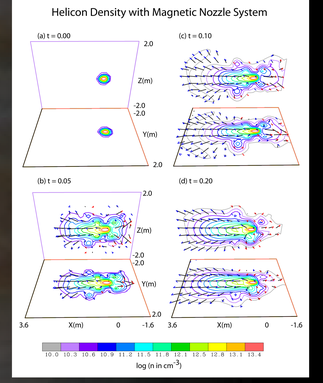
We consider three cases: (1) No Nozzle magnet, (2) With Nozzle magnet and (3) with deflector magnet. Configurations for Cases 1 and 2 are shown below.



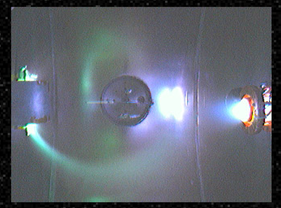


Examples showing broad plasma expansion and the deformation of the magnetic field that leads to some focusing of the plasma beam.

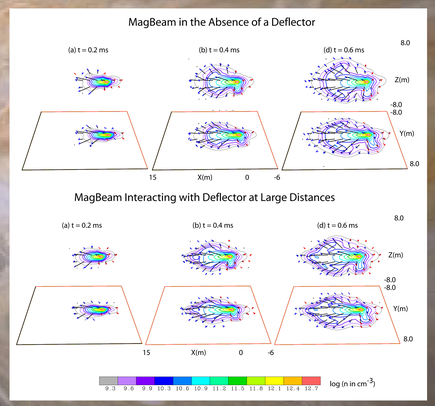
Enhanced performance with the addition of a magnetic nozzle



Deflector and Beam in Action Together



Computer Modeling Confirms Long Distance Focusing of Beam Energy into Deflector



Magnetic Reconnection Between Emitter and Deflector Allows Additional Focussing of MagBeam

Without Deflector **With Deflector**