Imperial College London

DESIGN AND EXPERIMENTAL QUALIFICATION OF THE SPHERICAL TOKAMAK THRUSTER: AN INNOVATIVE FUSION PLASMA PROPULSION SYSTEM

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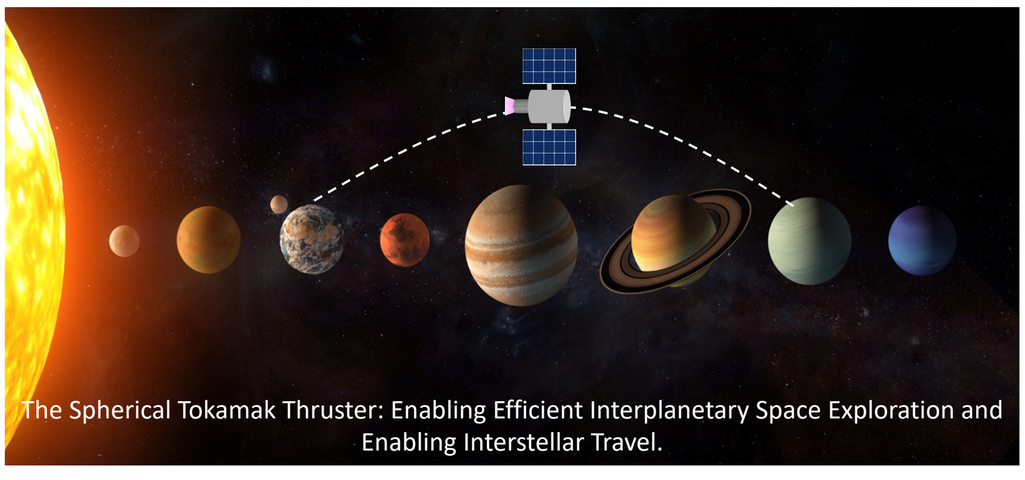
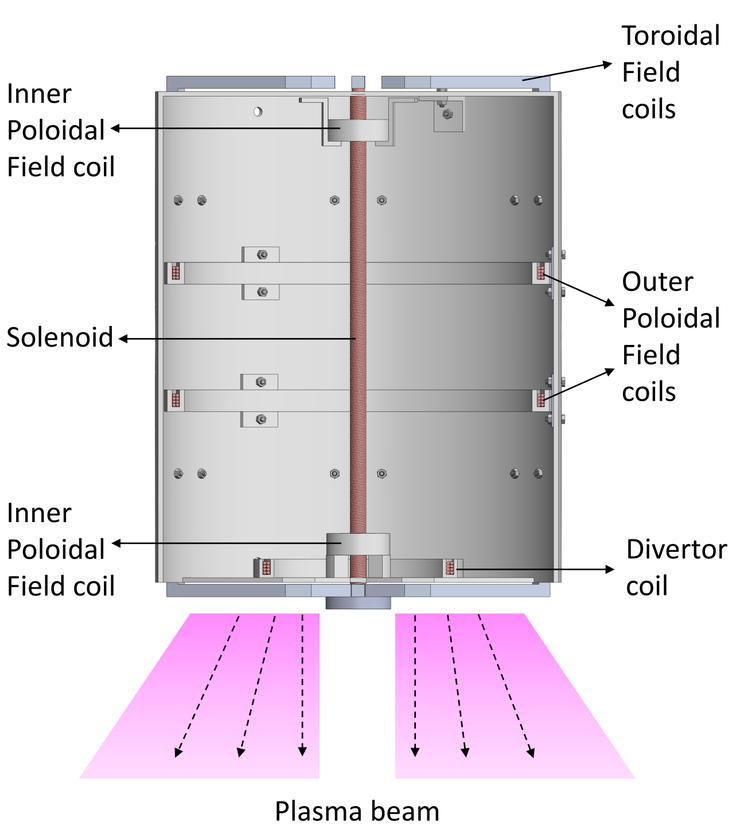
1. Introduction

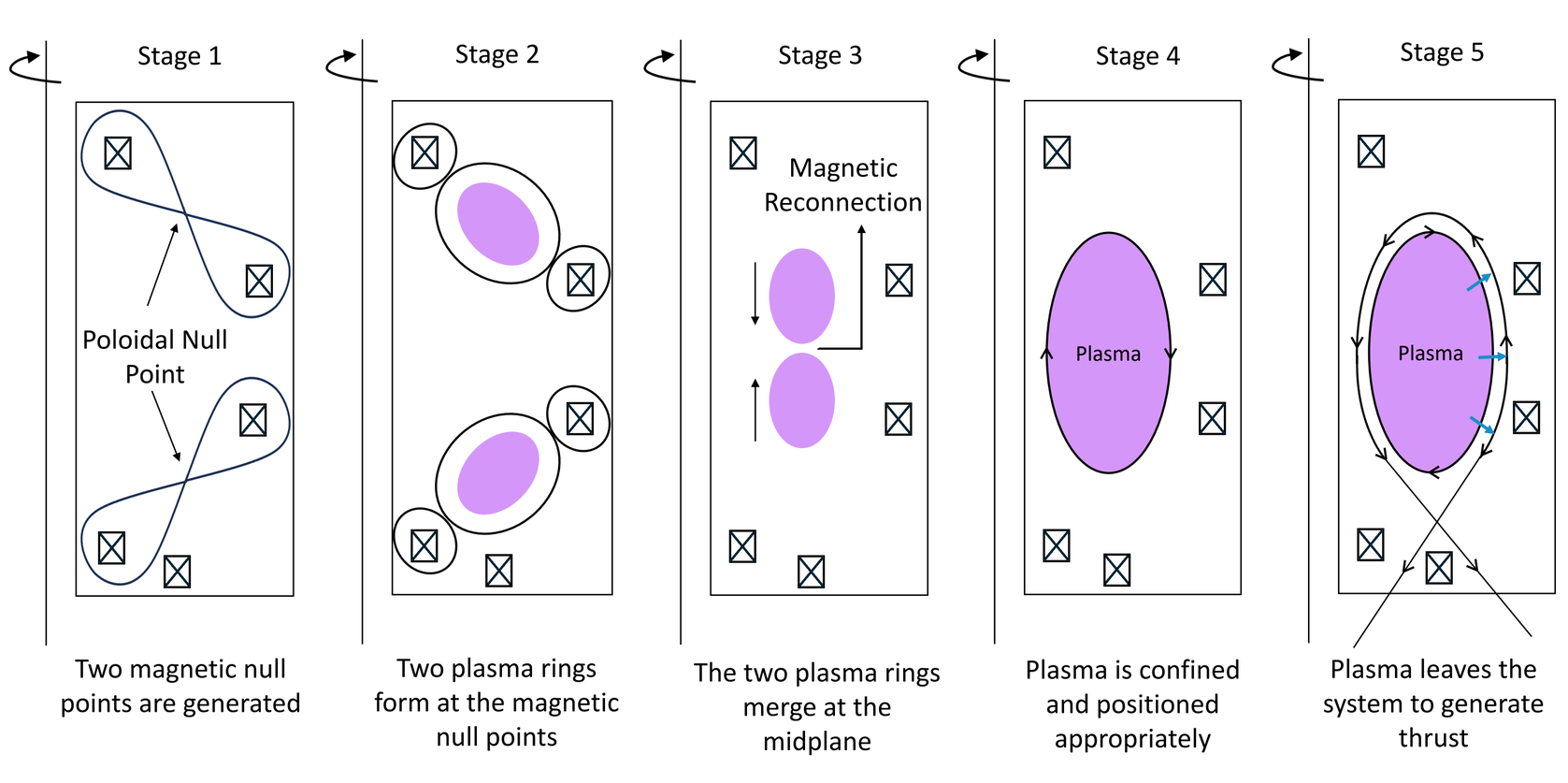
- With the increase in the number of manned and unmanned space exploration missions, the development of durable, reliable, powerful, and highly efficient propulsion systems is paramount.
- High power advanced electric propulsion systems with electrodeless designs and high efficiency are therefore essential, overcoming issues like electrode erosion and cathode poisoning.
- The Spherical Tokamak Thruster features an electrodeless design and offers exceptionally high specific impulse, dramatically reducing travel times for deep space missions.


The Spherical Tokamak Thruster: Enabling Efficient Interplanetary Space Exploration and Enabling Interstellar Travel.

2. Thruster Principles of Operation

- A process known as double null merging is used to generate two plasma rings in the upper and lower regions of the vessel using two sets of poloidal field coils.
- Once generated, the two spherical plasmas are merged at the midplane of the vessel through a phenomenon known as magnetic reconnection, which efficiently converts the stored magnetic energy to plasma thermal energy.
- The heated core plasma is confined by the toroidal and poloidal magnetic fields.
- A single null divertor magnetic field configuration is generated to divert the plasma towards the lower region of the device where it exits into the vacuum of space, thereby generating thrust.



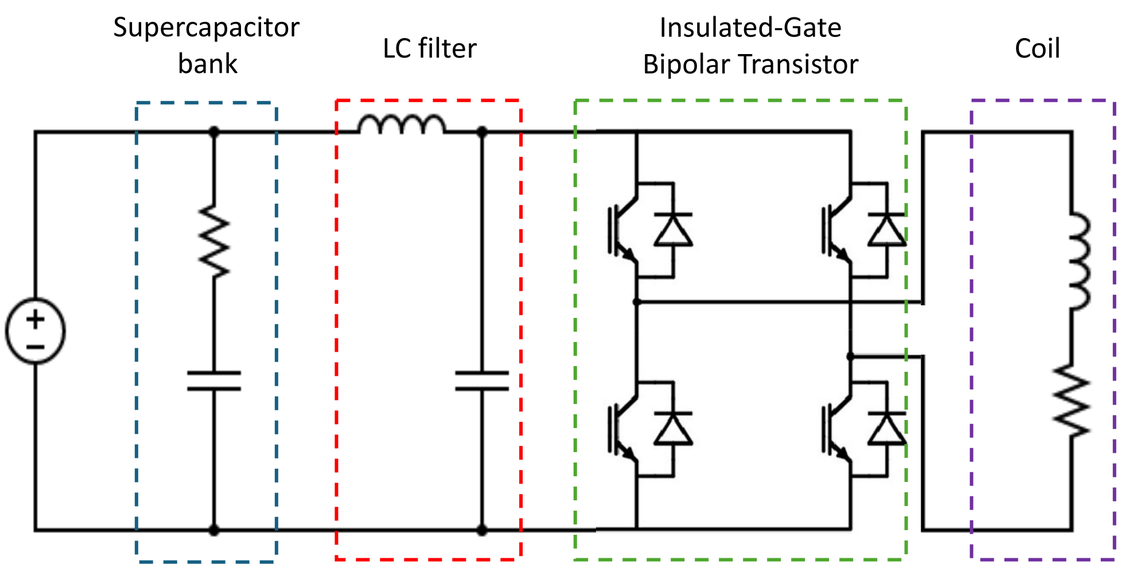


3. Thruster Specification

Parameter	Value
Dimensions	25 cm (OD) X 33 cm (H)
Power	1 MW
Mass	1.82 kg
Propellant	Wide range (atomic and molecular) including H_2O
Pulse Duration	2 ms
Specific Impulse	30000 s

4. Power Supply Design

The conceptual design of all coil driver circuits will follow the basic concept of full bridge IGBT modules arranged in H bridge configuration, shown schematically below.



5. Conclusion

- A novel electrodeless high power thruster concept, inspired by the operating principles of spherical tokamaks and magnetic confinement fusion, is presented.
- This thruster marks a notable advancement in high power plasma propulsion technology, setting an unprecedented standard as the very first of its kind.