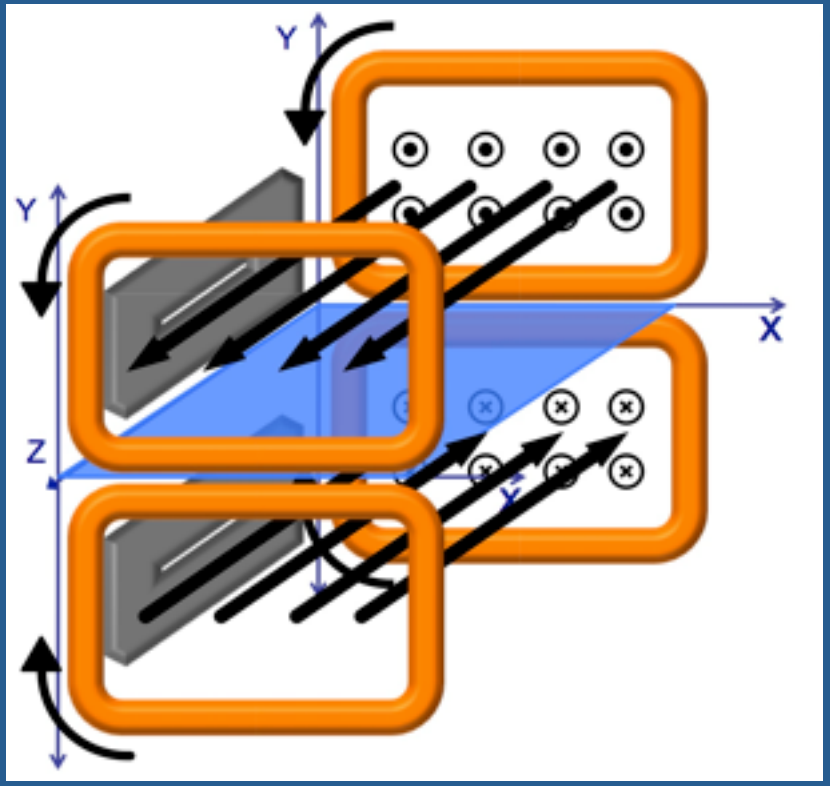
Magnetic Null Thruster

A Novel Concept for Plasma Propulsion

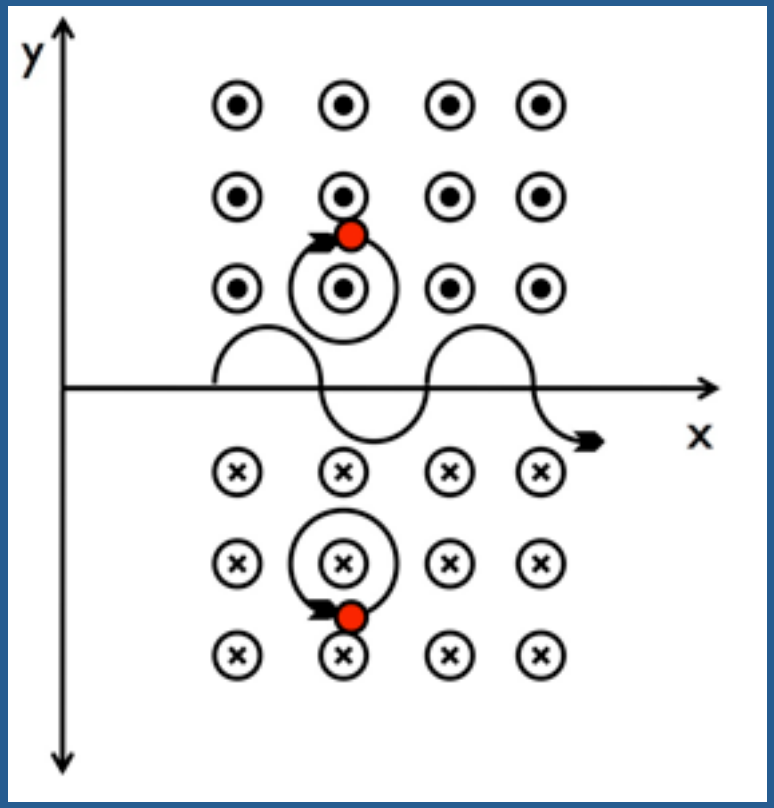
Charlie Kelly ‘14

Magnetic Null

- Two large opposing uniform fields
- Plane in between is Magnetic Null
- Purpose: direct ions out



Mechanism



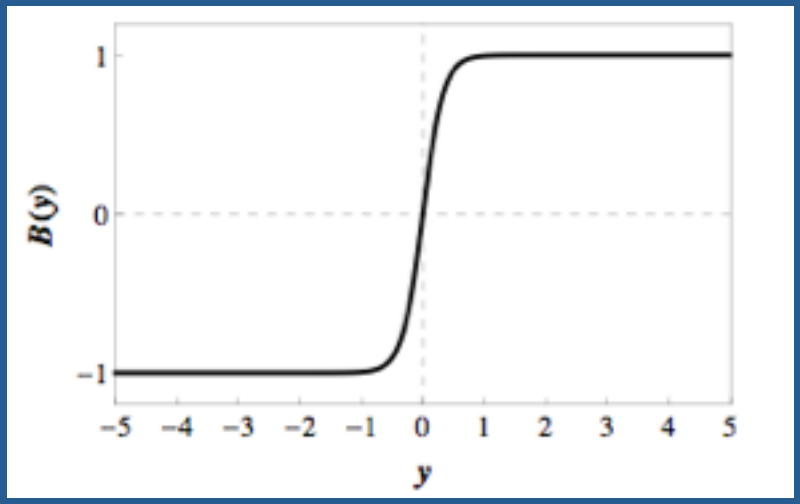
- Ions trapped in Larmor orbits
- Reverse orbit direction upon crossing null
- If ion crosses null, it will exit thruster
- Problem: acceleration

Beating Electrostatic Wave Heating

- Majority of ions will never cross null
  - Need to accelerate them
- Three acceleration regimes
  - Forbidden
  - Regular
  - Stochastic

Previous Work

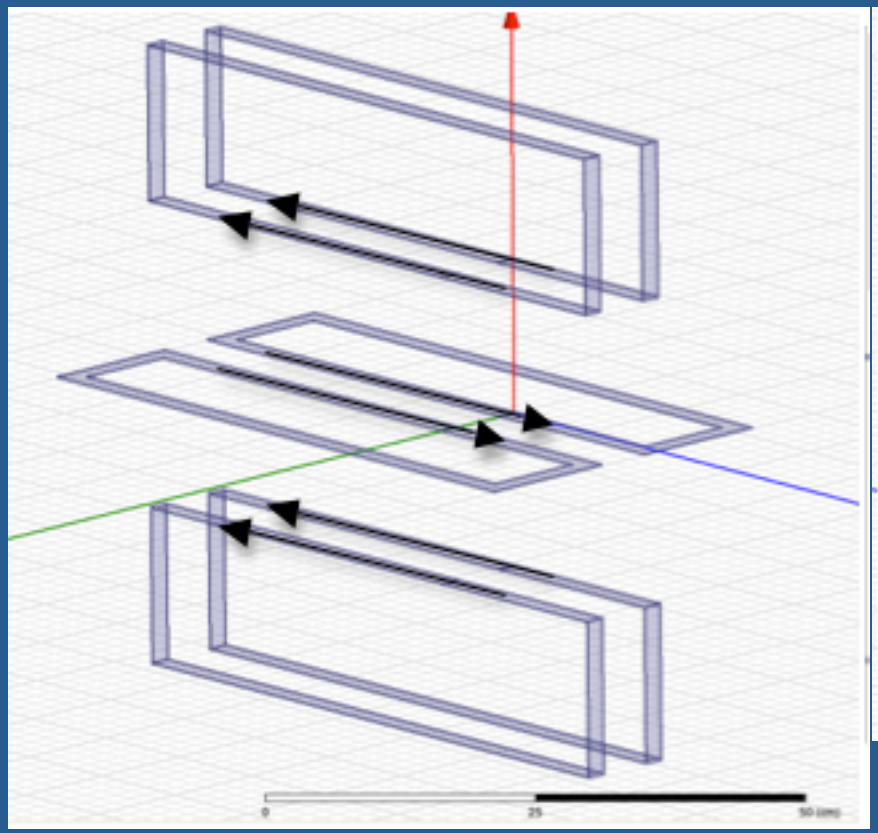
- Proof-of-concept
  - Idealized magnetic null
  - No constraints on realism
- Performance
  - Theoretical I_{sp} ~ 1500 s
  - Comparable to existing thrusters

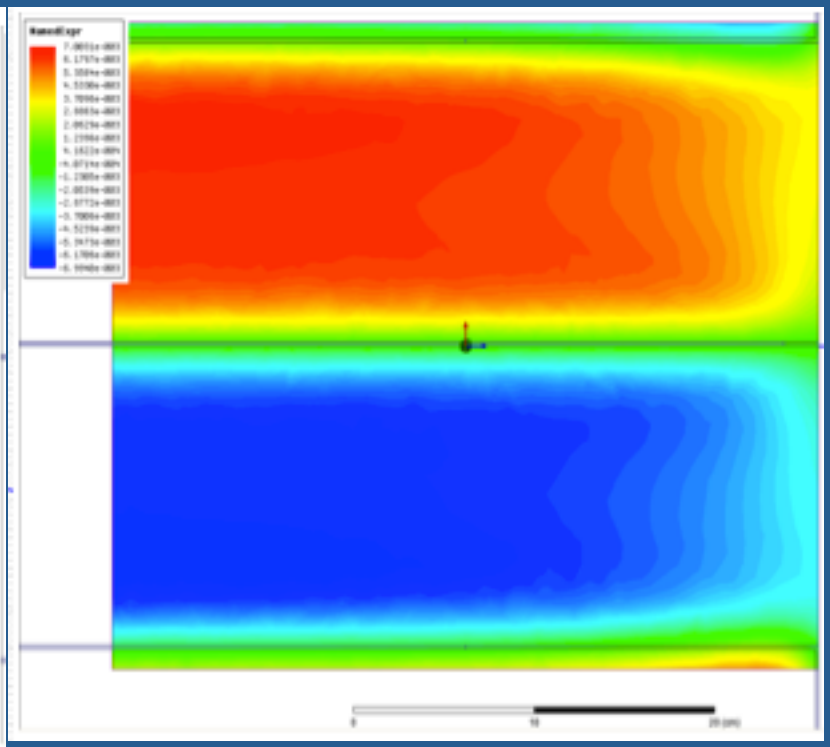


My Project

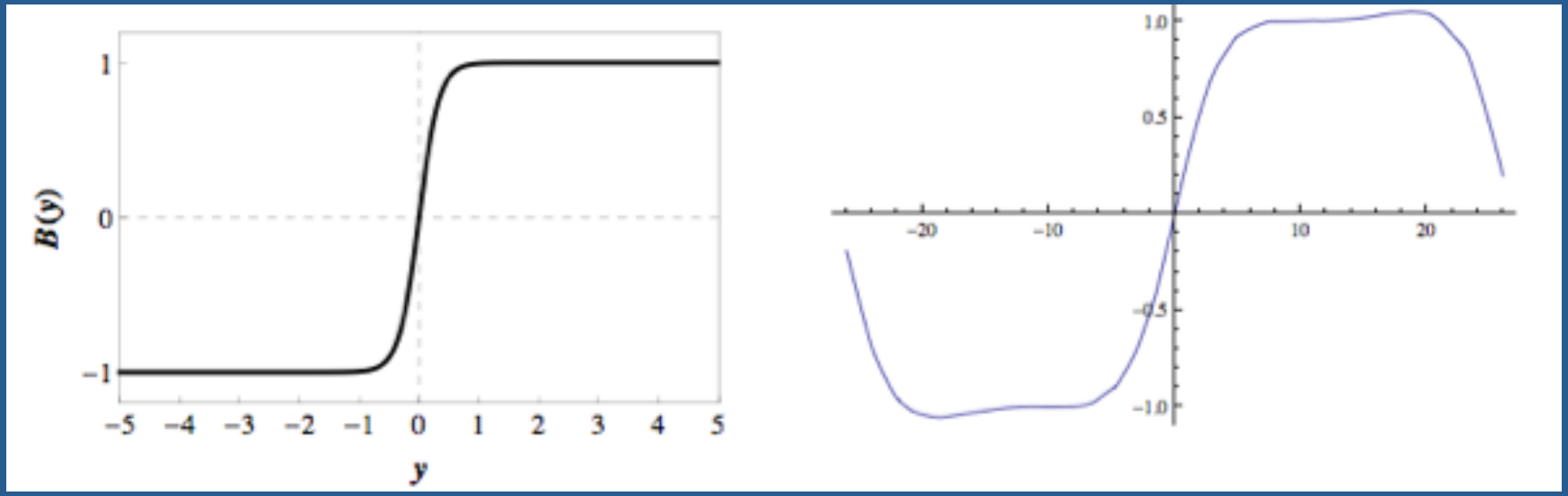
- Design electromagnetic coil arrangement to generate a real magnetic null
- Run performance simulations using generated null
- Determine feasibility of building a real Magnetic Null Thruster

Coil Design





Generated Null



Four Simulations

- Unrealistically large thruster
  1. Ideal wave parameters
- Realistic thruster size
  2. Ideal wave parameters
  3. Weak waves
  4. No waves

Simulation Results

Simulation Conditions	I_{sp} (s)	% of ions exited
Large Thruster, Ideal Wave Parameters	1170	85%
Realistic Thruster, Ideal Wave Parameters	1040	79%
Realistic Thruster, Weak Waves	700	50%
Realistic Thruster, No Waves	60	5%

Simulation Results

Simulation Conditions	I_{sp} (s)	% of ions exited
Large Thruster, Ideal Wave Parameters	1170	85%
Realistic Thruster, Ideal Wave Parameters	1040	79%
Realistic Thruster, Weak Waves	700	50%
Realistic Thruster, No Waves	60	5%

Conclusion

- Magnetic Null Thruster is a feasible concept
- Results justify construction of physical device
- Future work
  - Improve design of coils with ferrite materials
  - Run 3D analysis
  - Test in vacuum chamber
  - BEW heating?