Inertial Electrostatic Confinement Amplified Fusion Propulsion

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Getting to Mars and Beyond

Why are we not there yet?

Need Higher *Specific Impulse* then what chemical rockets are capable of providing

A more efficient engine has a higher specific impulse because it produces more thrust for the same amount of propellant

- Specific Impulse:

$$\frac{Thrust}{Weight\ Flow\ Rate}$$

- Thrust of a Rocket:

$$Mass\ Flow\ Rate \times Exit\ Velocity$$

Exit Velocity is Limited by Chemical Reactions

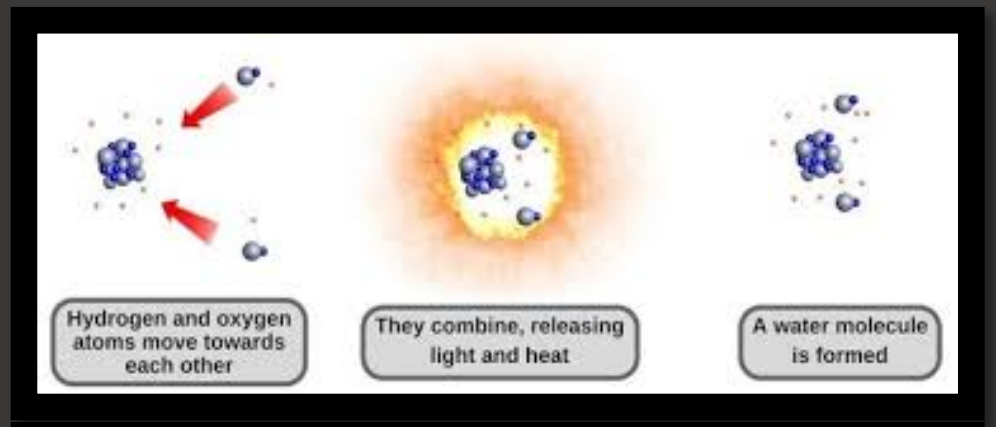
Chemical vs. Fusion Fuel

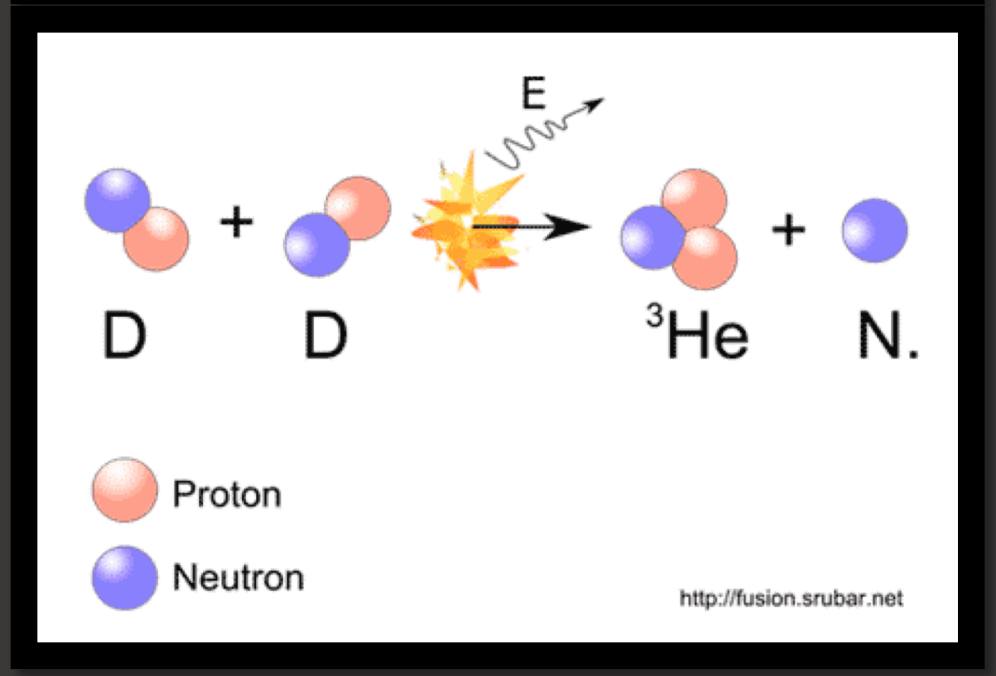
Combustion of Hydrogen and Oxygen

~ 13 MJ / Kg

Fusion of Deuterium with Deuterium

~ 300 Million MJ / Kg

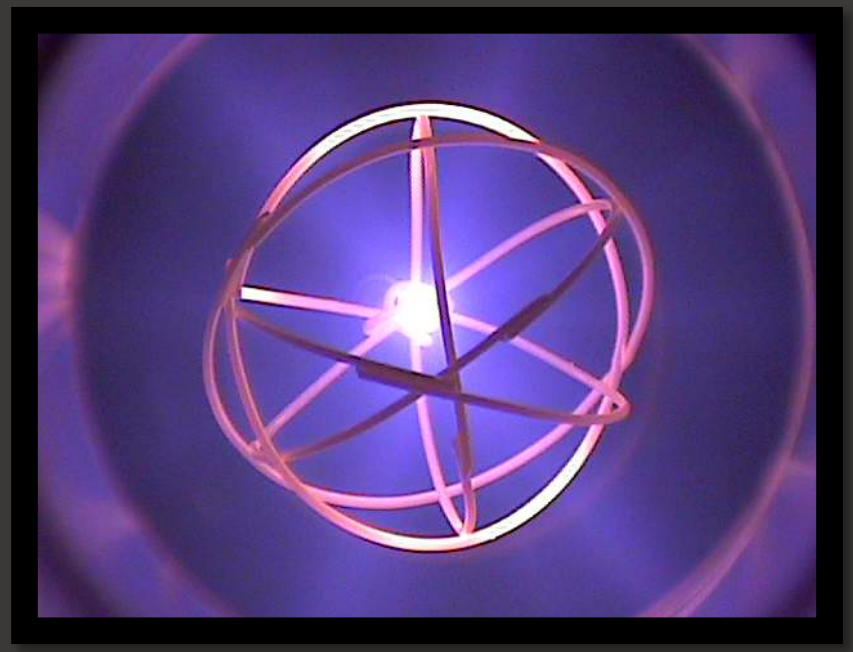




Put in perspective: Saturn 5 carried roughly ***2 million Kg*** of Chemical Fuel (first stage)

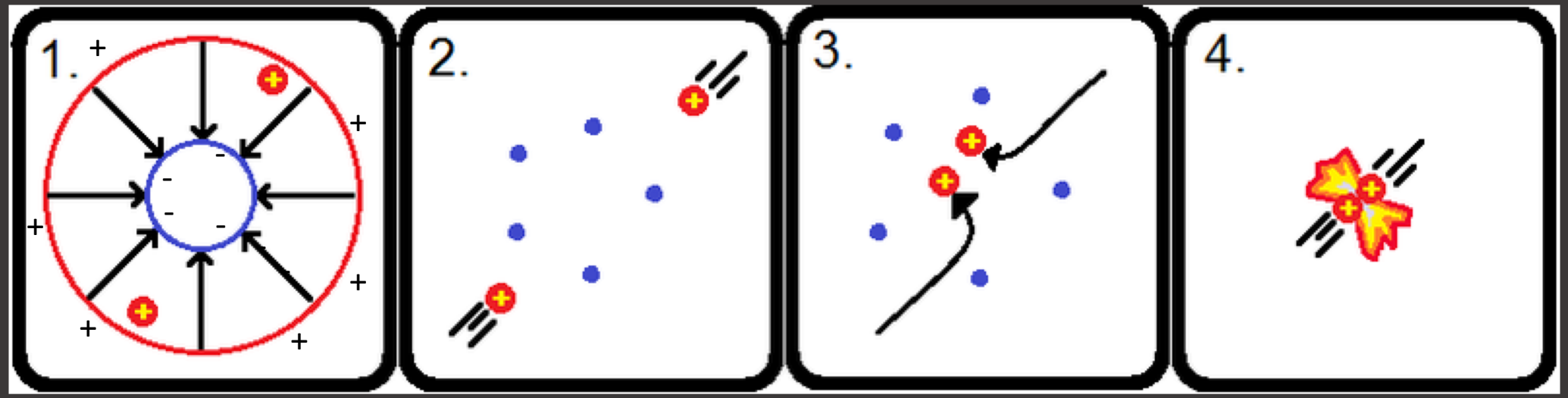
The equivalent amount of Fusion Fuel to deliver the same energy is *94 grams*

Electrical Energy → **Fusion Energy** → **Kinetic Energy**



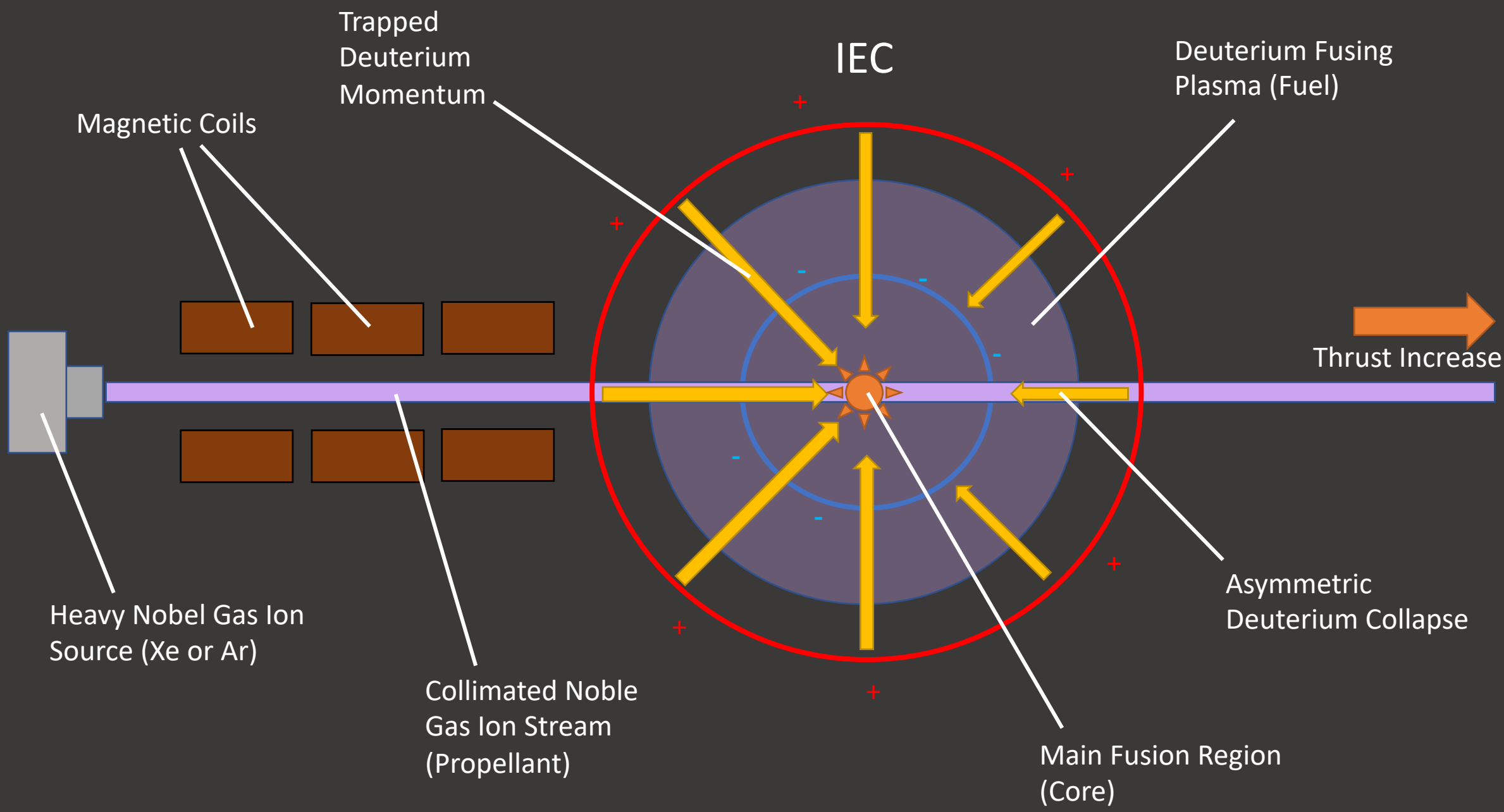
Inertial **E**lectrostatic **C**onfinement (**IEC**)

- Relatively easy to get plasma to fusion conditions (compared to magnetic confinement)



1. Deuterium gas enters the IEC devise and is ionized
2. Positive ions are accelerated towards the center due to grid potential
3. Ions pass through center many times
4. Fusion occurs in a fraction of passes

Phase 1	Phase 2
Construct small scale plasma devices Characteristics: ➢ No Fusion ➢ Small-scale models ➢ Varies Grid configurations Objectives: ➢ Study plasma behavior ➢ Gain understanding behind mechanics of fusors ➢ Gain necessary hardware manufacturing skills (i.e. Vaccum systems) ➢ Troubleshooting all subsystems	Construct Larger-scale fusion core thruster Characteristics: ➢ Deuterium ignition Fuel ➢ Incident propellant stream of large noble gas particles (IPS) Objectives: ➢ Increase energy of IPS* with fusion fuel in IEC and direct it to produce thrust. ➢ Test geometries of IEC core grid ➢ Collect Thrust and Fusion energy data


Trapped
Deuterium
Momentum
IEC
Deuterium Fusing
Plasma (Fuel)
Magnetic Coils
Thrust Increase
Heavy Nobel Gas Ion
Source (Xe or Ar)
Collimated Noble
Gas Ion Stream
(Propellant)
Asymmetric
Deuterium Collapse
Main Fusion Region
(Core)

Study the Transfer of Fusion Energy to Thrust Kinetic Energy

Verify Fusion is occurring, fusion rate, and amount of energy being produced

Verify there is an increase in thrust during IEC operation

Measurement of Fusion Energy in IEC

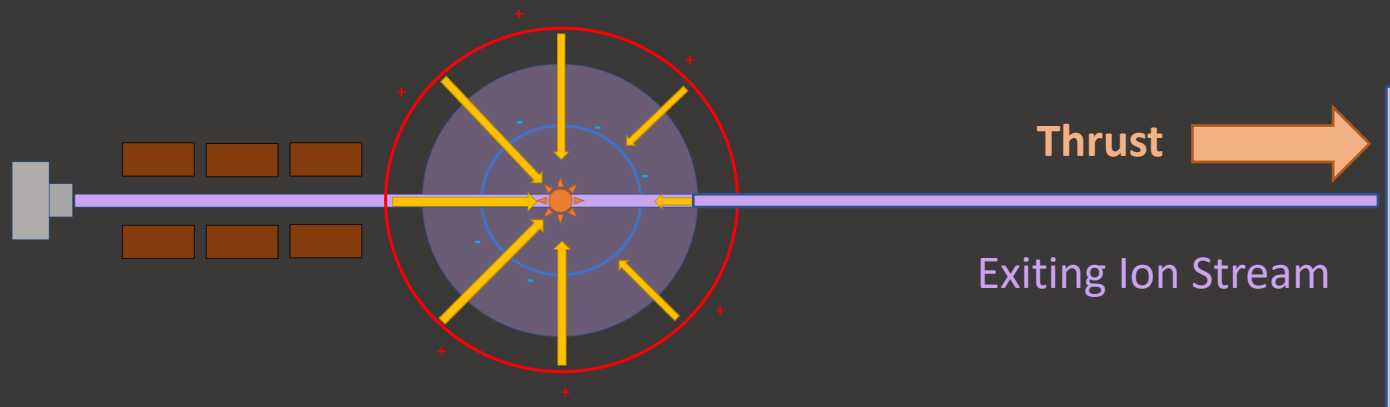
- Measure Neutron Rate and Energy in IEC with Scintillation Neutron Detector
- Use Rate, Energy, and Solid Angle of Porthole to Measure Fusion Rate in Core
- Use Fusion Rate in Core to Calculate Helium Kinetic Energy Flux

$$ {}_{1}^{2}D + {}_{1}^{2}D \rightarrow {}_{2}^{3}He + {}_{0}^{1}n + 3.27\ MeV $$

$$ E_{NEUTRON} = Q\ x\ \frac{mass\ of\ helium}{mass\ of\ neutron + helium} = 2.45\ \text{MeV} $$

$$ E_{HELIUM} = Q\ x\ \frac{mass\ of\ neutron}{mass\ of\ neutron + helium} = 0.82\ \text{MeV} $$

Measurement of Thrust

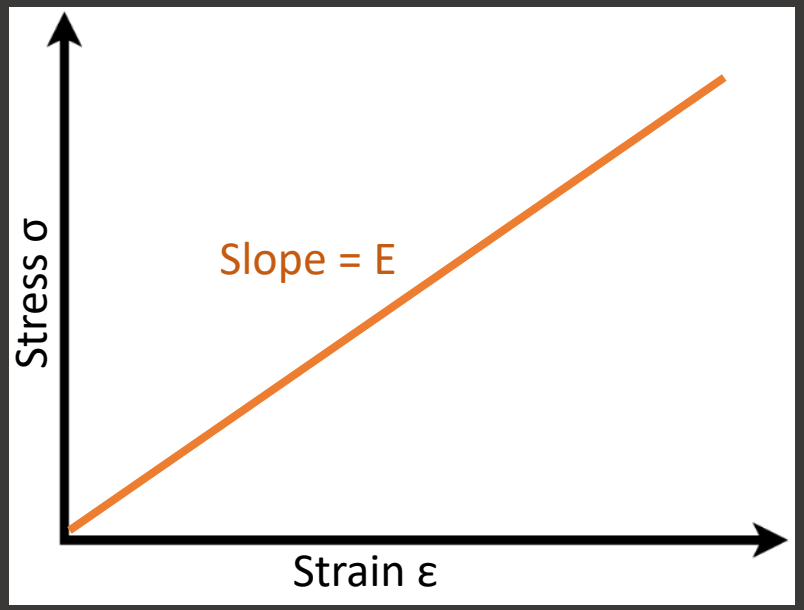


Thrust

Exiting Ion Stream

Strain Gauge

Cantilever Beam



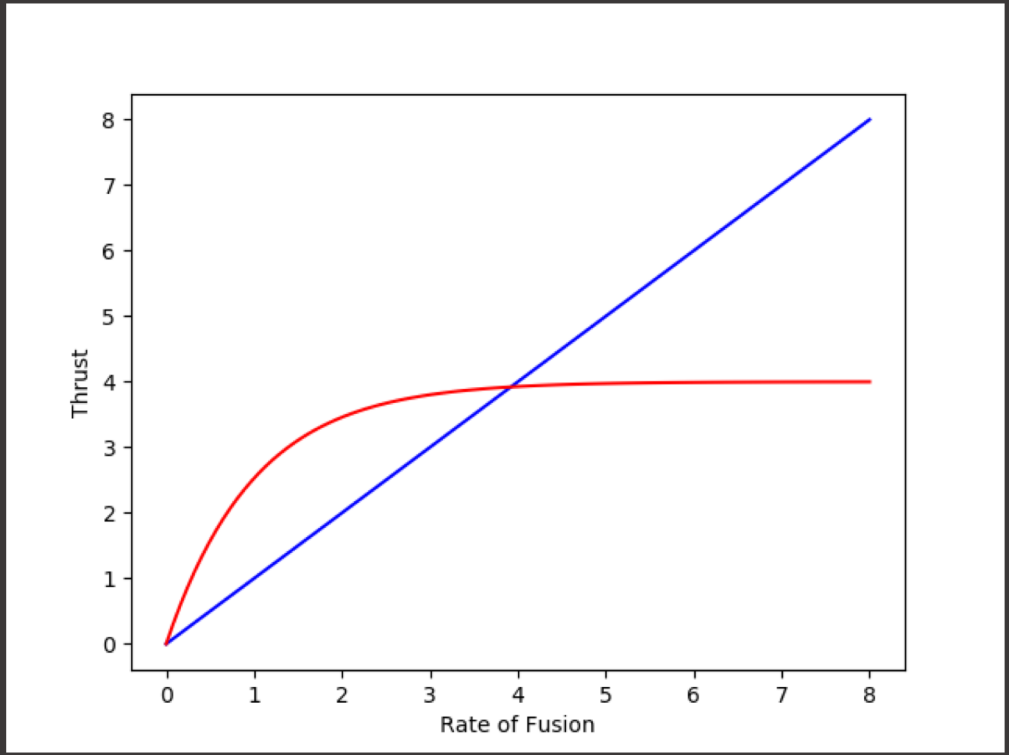
$$\sigma = E\varepsilon$$

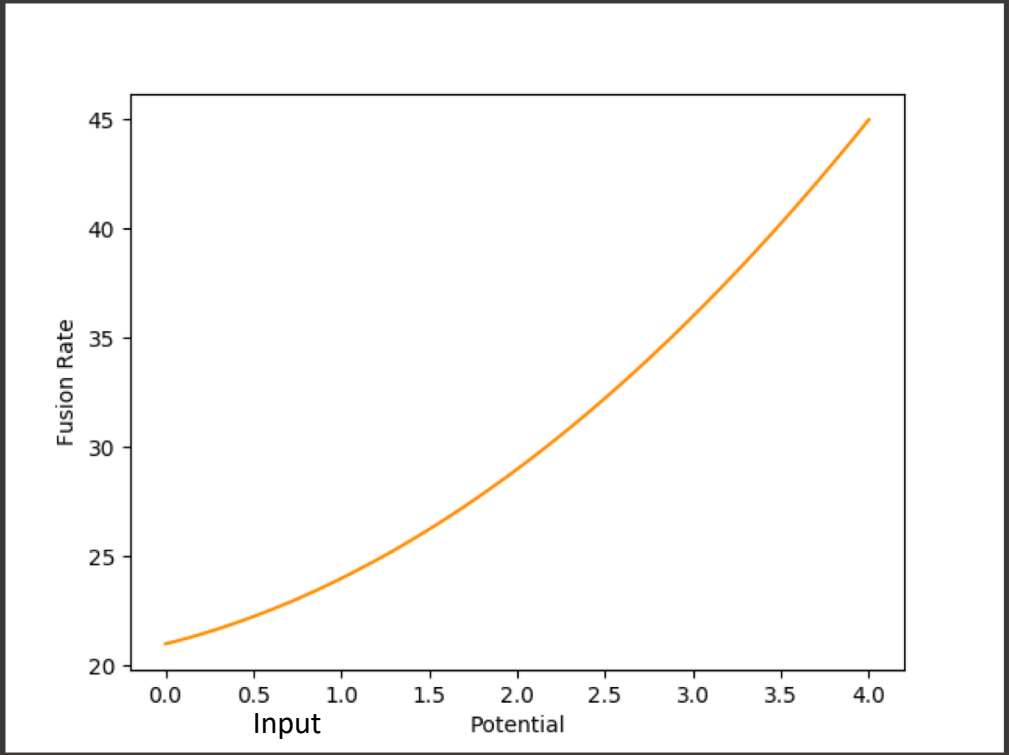
$$M = -\frac{\sigma I_z}{y}$$

$$F_{THRUST} = \frac{M}{y}$$

Proposed Measurement Relationships

(Hypothetical; to be determined)





Citations:

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