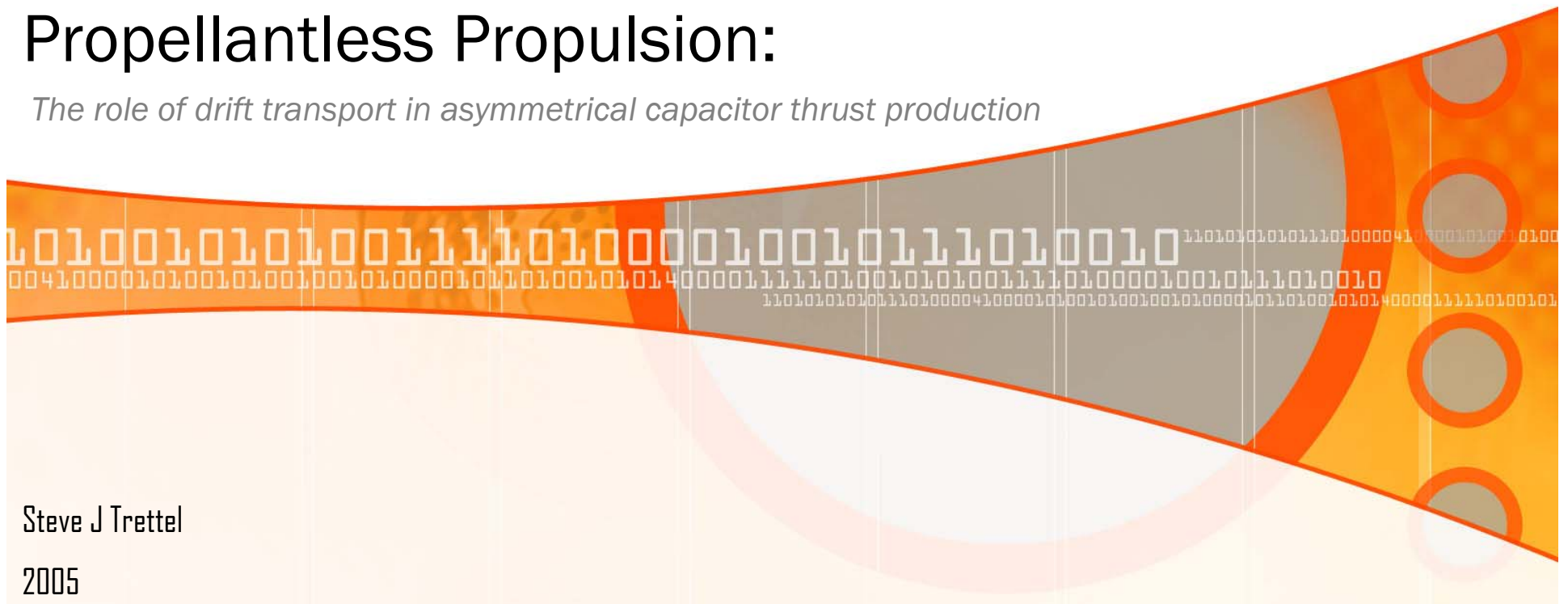


Propellantless Propulsion:

The role of drift transport in asymmetrical capacitor thrust production



Steve J Trettel

2005

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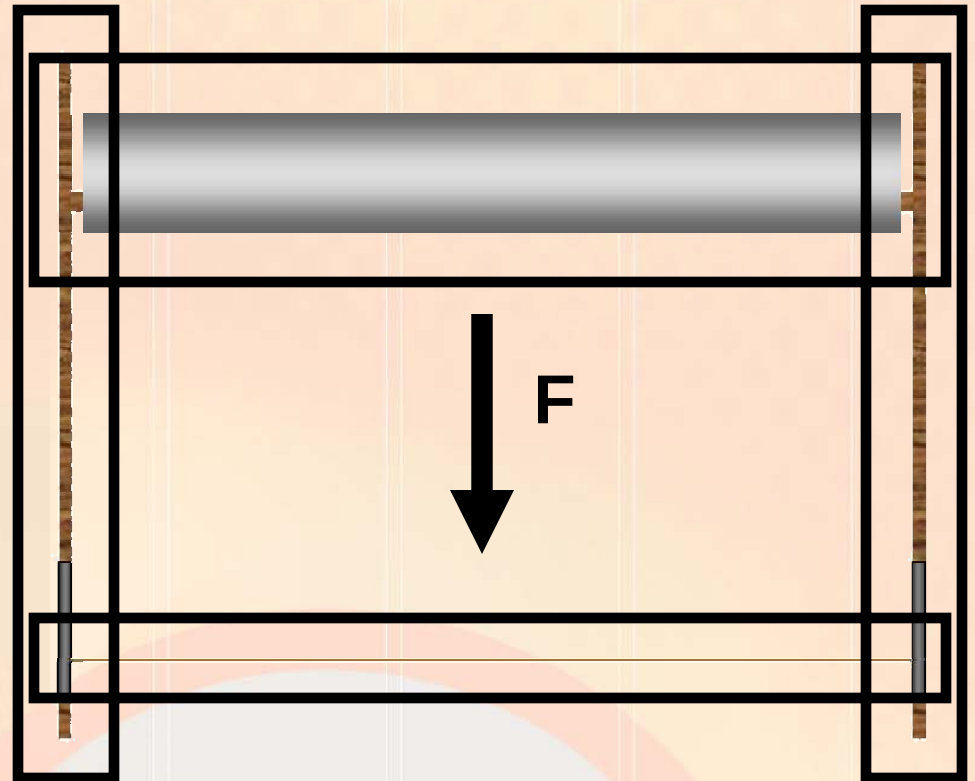
ASYMMETRICAL CAPACITORS

- Produces net force when charged
- No moving parts
- Silent Operation



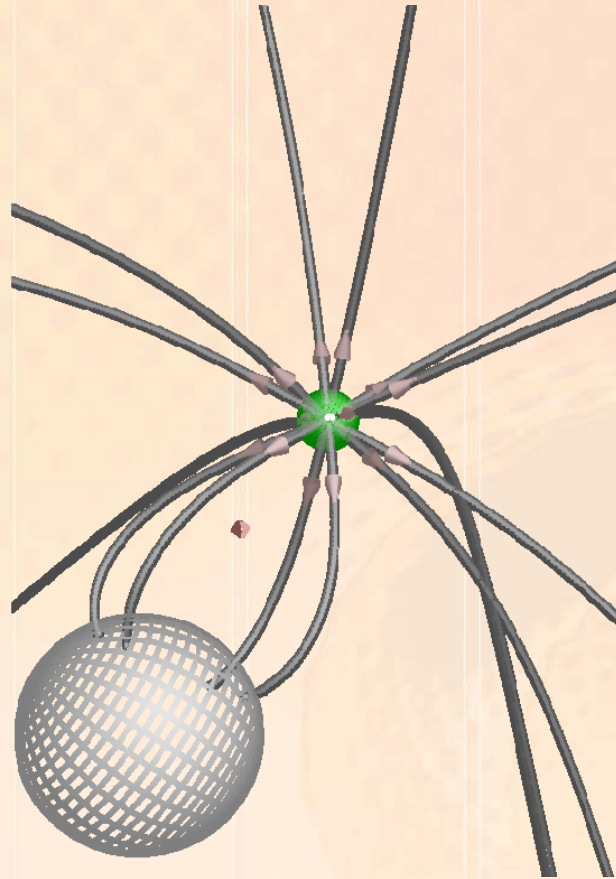
ASYMMETRICAL CAPACITORS

- Geometrically dissimilar electrodes
- Isolative supports
- High Voltage (26kV, 300uA)
- Force in direction of smaller electrode



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PHYSICS



- **“This thrust cannot be presently explained by any previous theories...”**

- Purdue University, 2000

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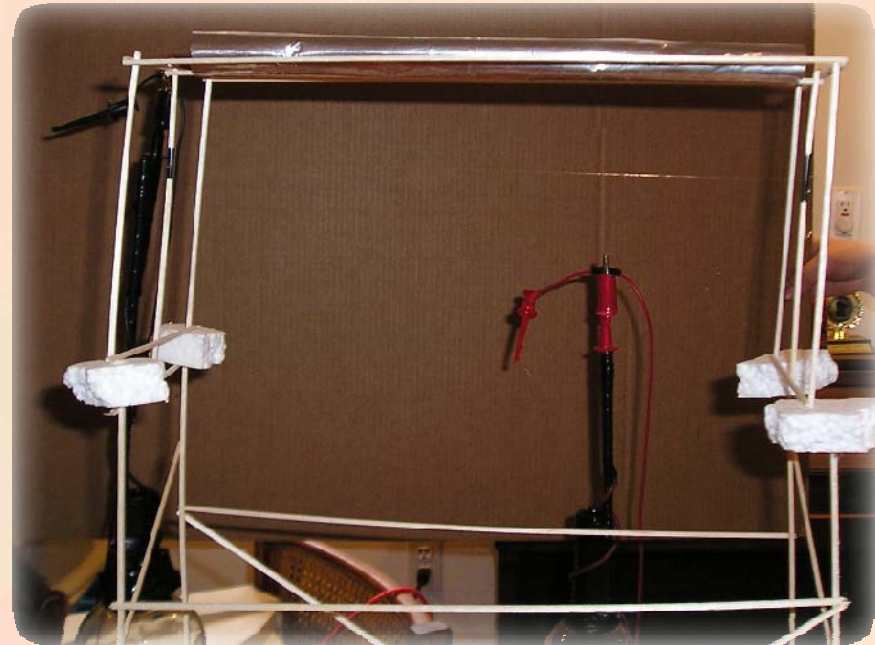
OBJECTIVE

- Evaluate the effect of the following on the direction/magnitude of the resulting thrust:
 - SEPERATION
 - ASYMMETRY
 - POLARITY
- Analyze results mathematically and look for possible theories

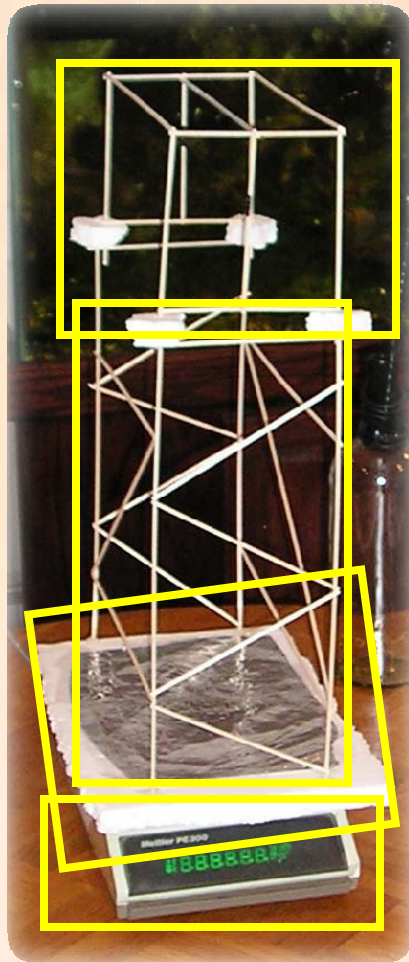


HYPOTHESIS

- Force is proportional to the electric field strength and the flux through the foil electrode
- Force will only be produced when the wire electrode is charged

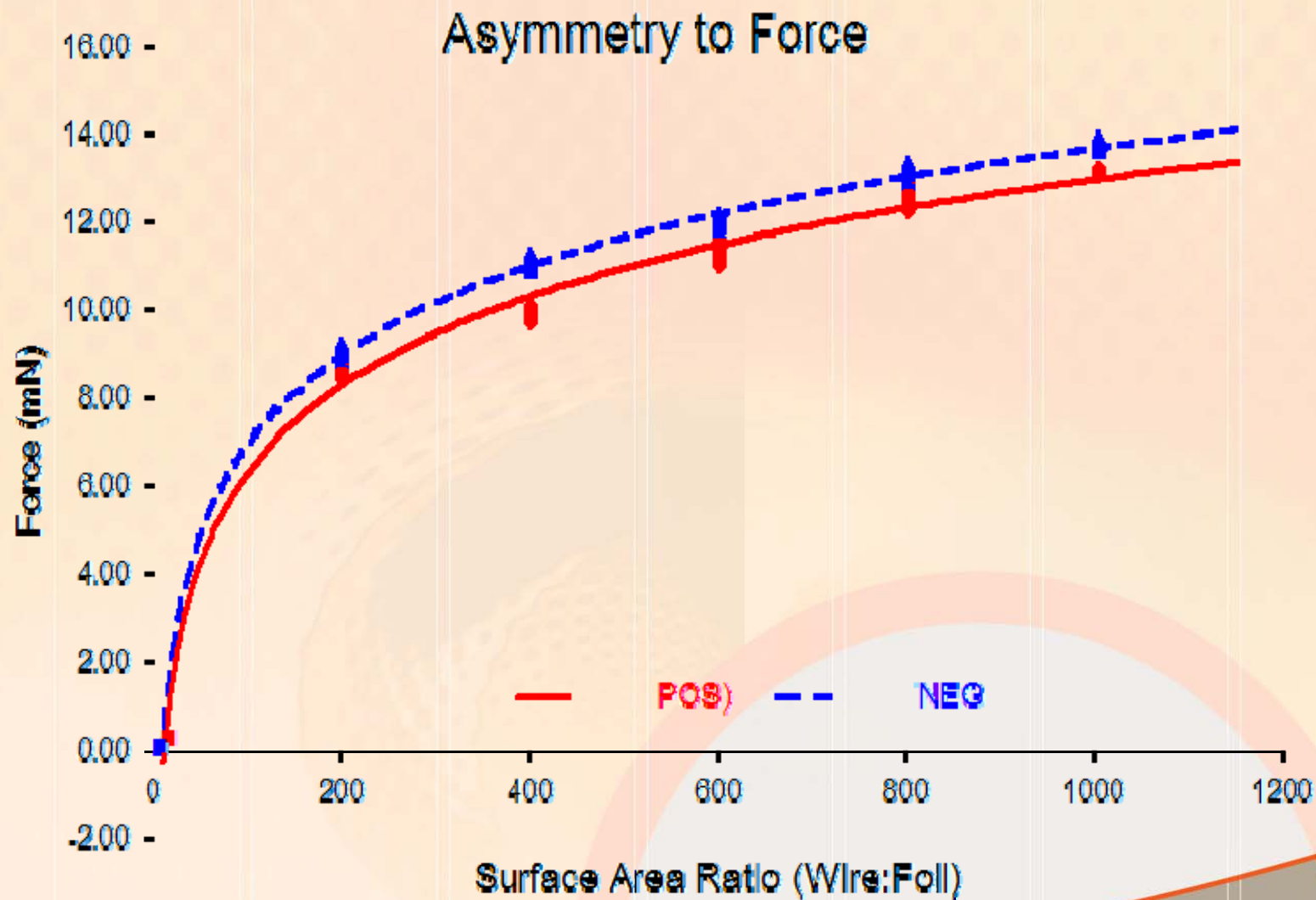


PROCEDURE



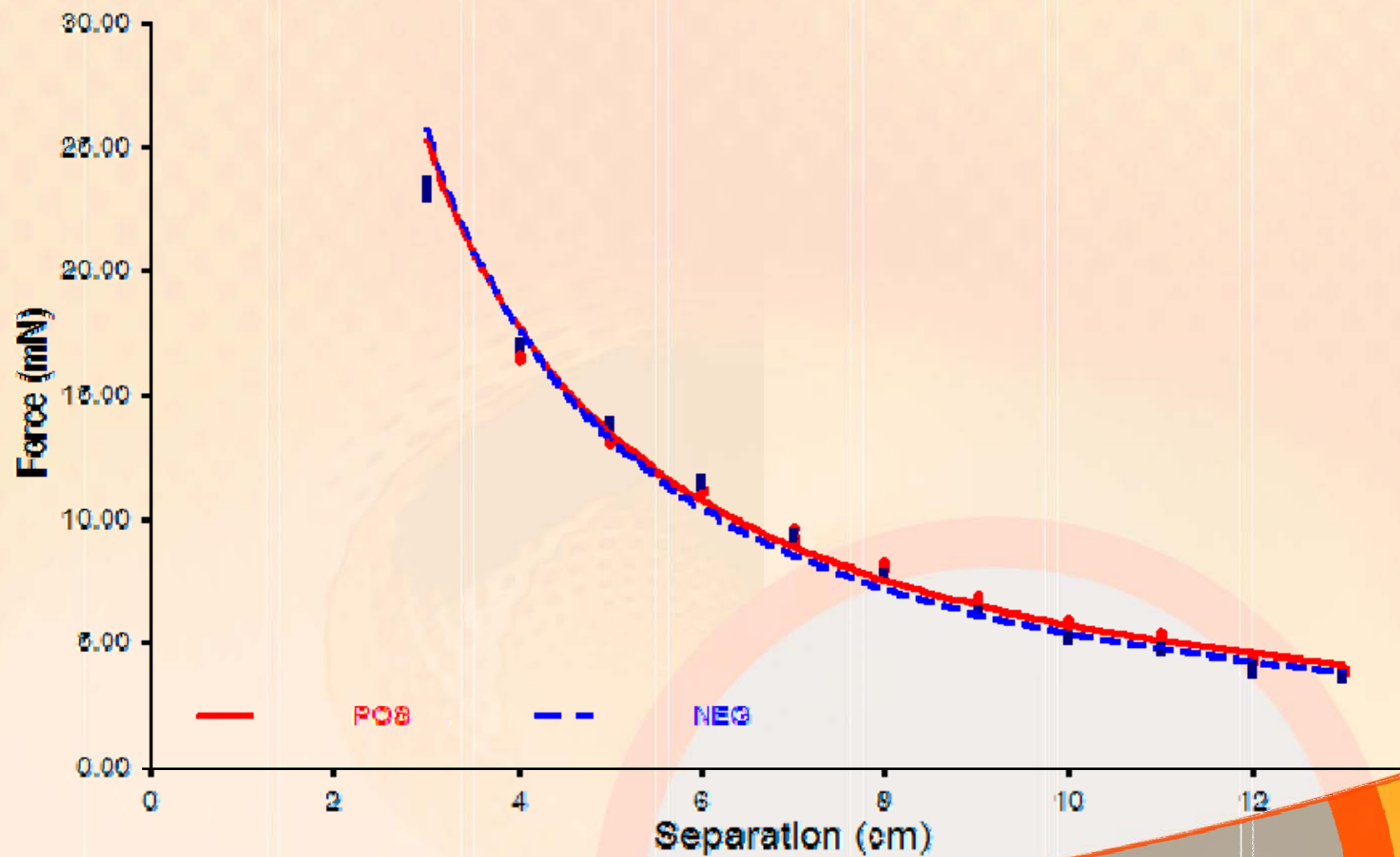
- Configuration positioned so force is downward
- Placed on electronic balance with support stand
- When charged, thrust is measured as an increase in weight
- Quickly and accurately obtained results

ASYMMETRY



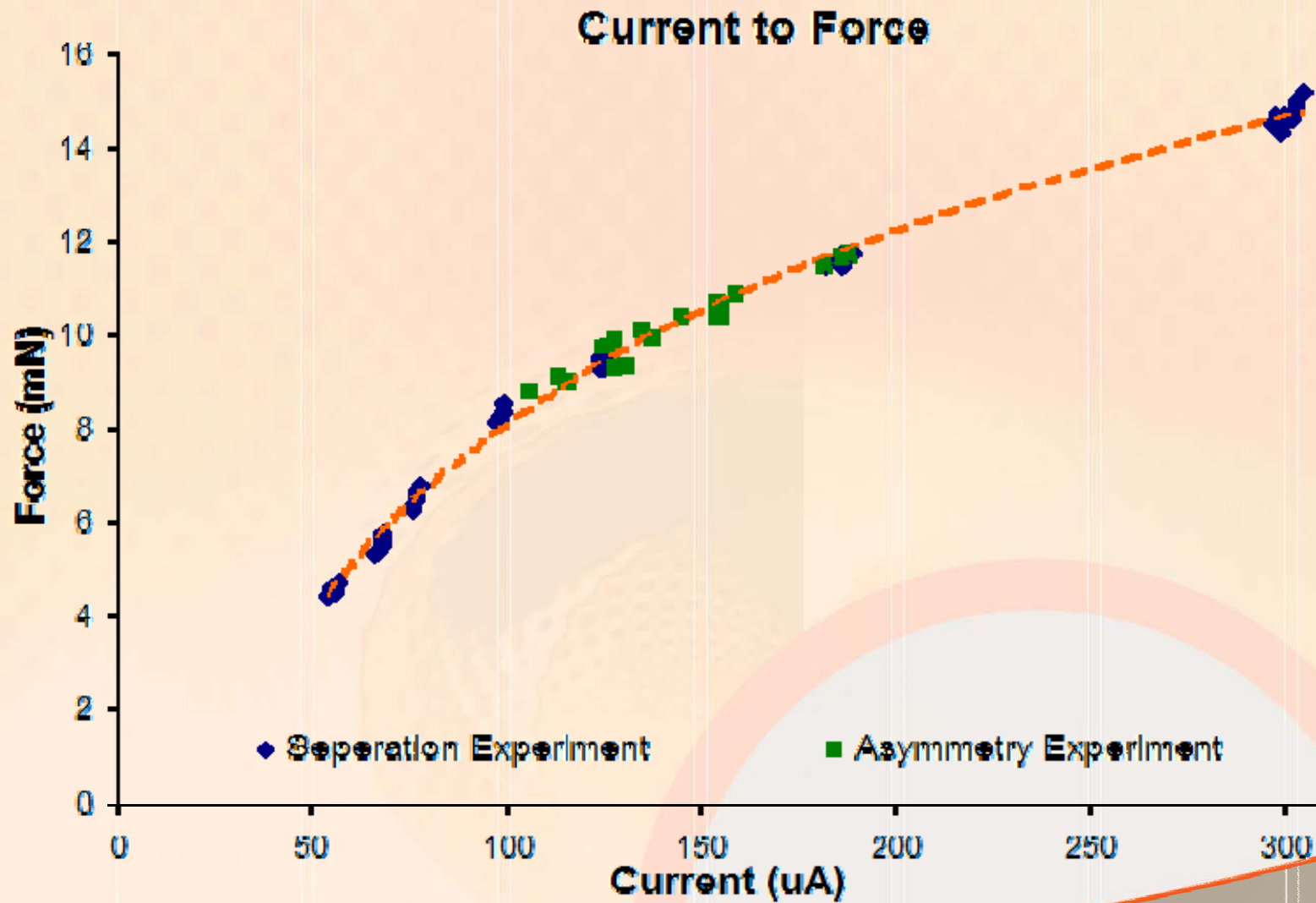
ELECTRODE SEPARATION

Separation to Force

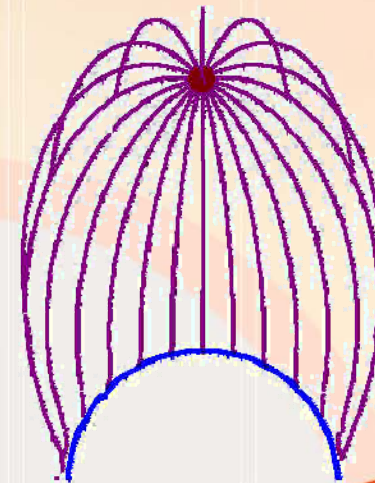
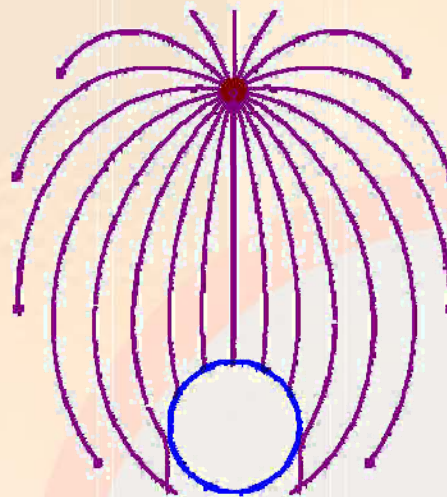
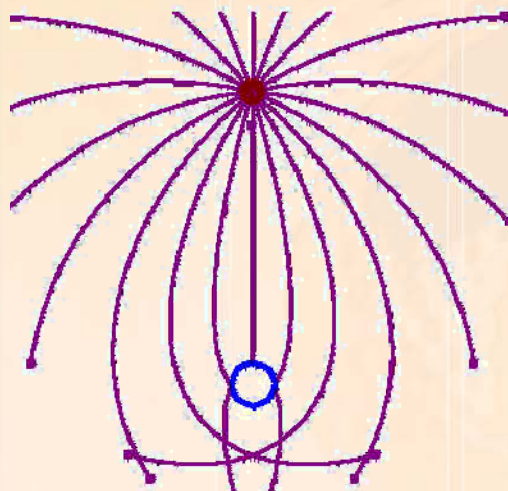
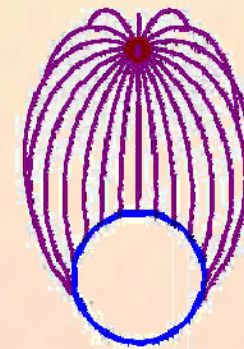
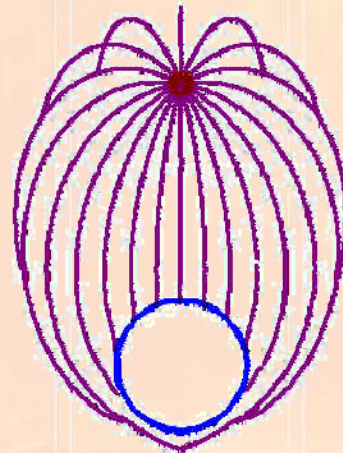
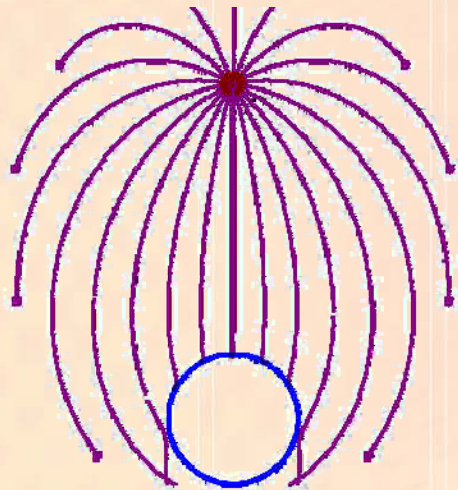


CURRENT

RESULTS



ELECTRIC FIELD



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ION WIND

Ions move between ionizing and non-ionizing electrode

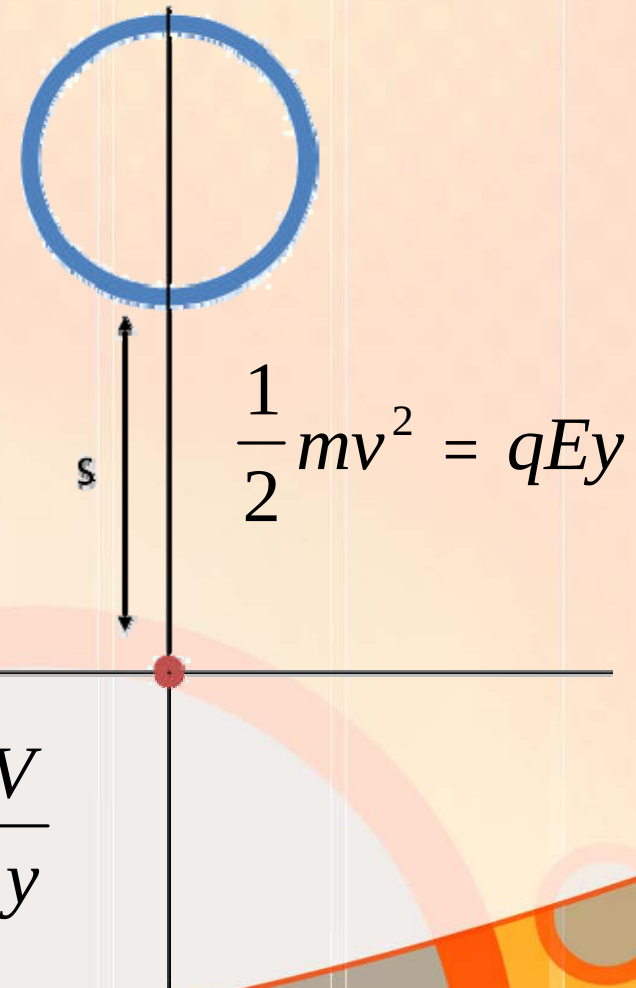
Mechanism comparable to ion thruster

$$F = I \sqrt{\frac{2mV}{q}}$$

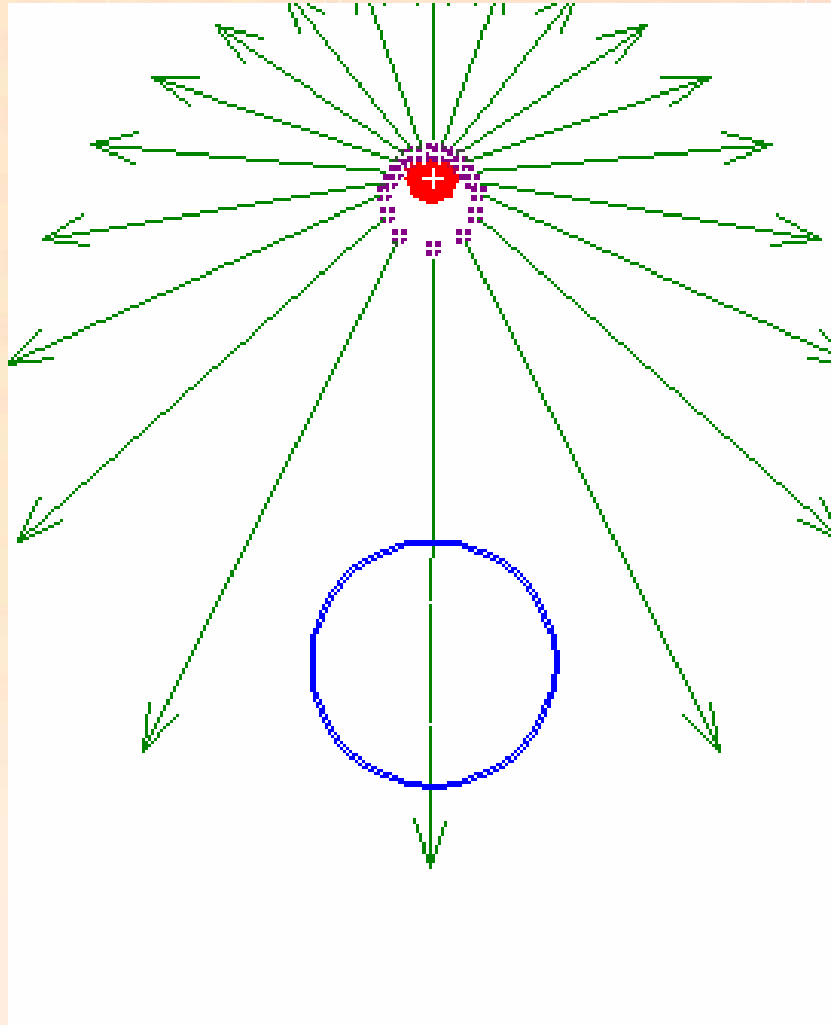
Theory predicts
0.00007N.

Experiment showed
0.018N

$$E = \frac{V}{s} = \frac{V}{y}$$



DRIFT TRANSPORT

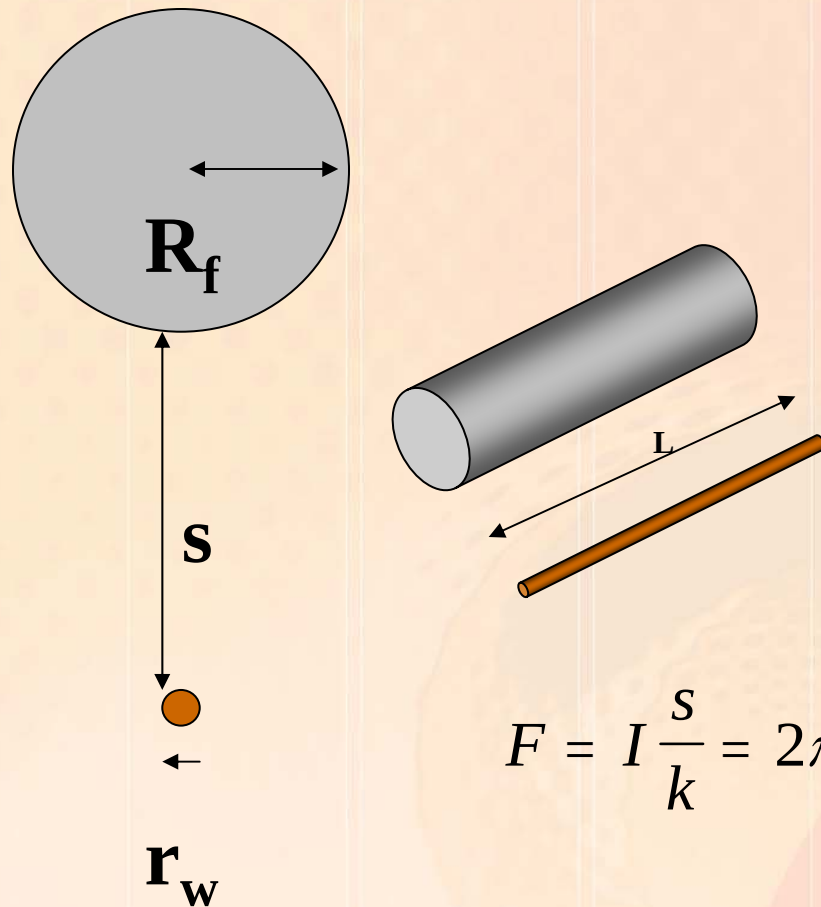


- Single ionizing electrode
- Ions impact molecules of dielectric
- Transfer momentum

$$F = qE = I \frac{s}{k}$$

Current is a complicated function of voltage, separation, and electrode geometry.

BARSOUKOV THEORY



Theory of current flow between two electrodes

Current is substituted into previous derivation of force

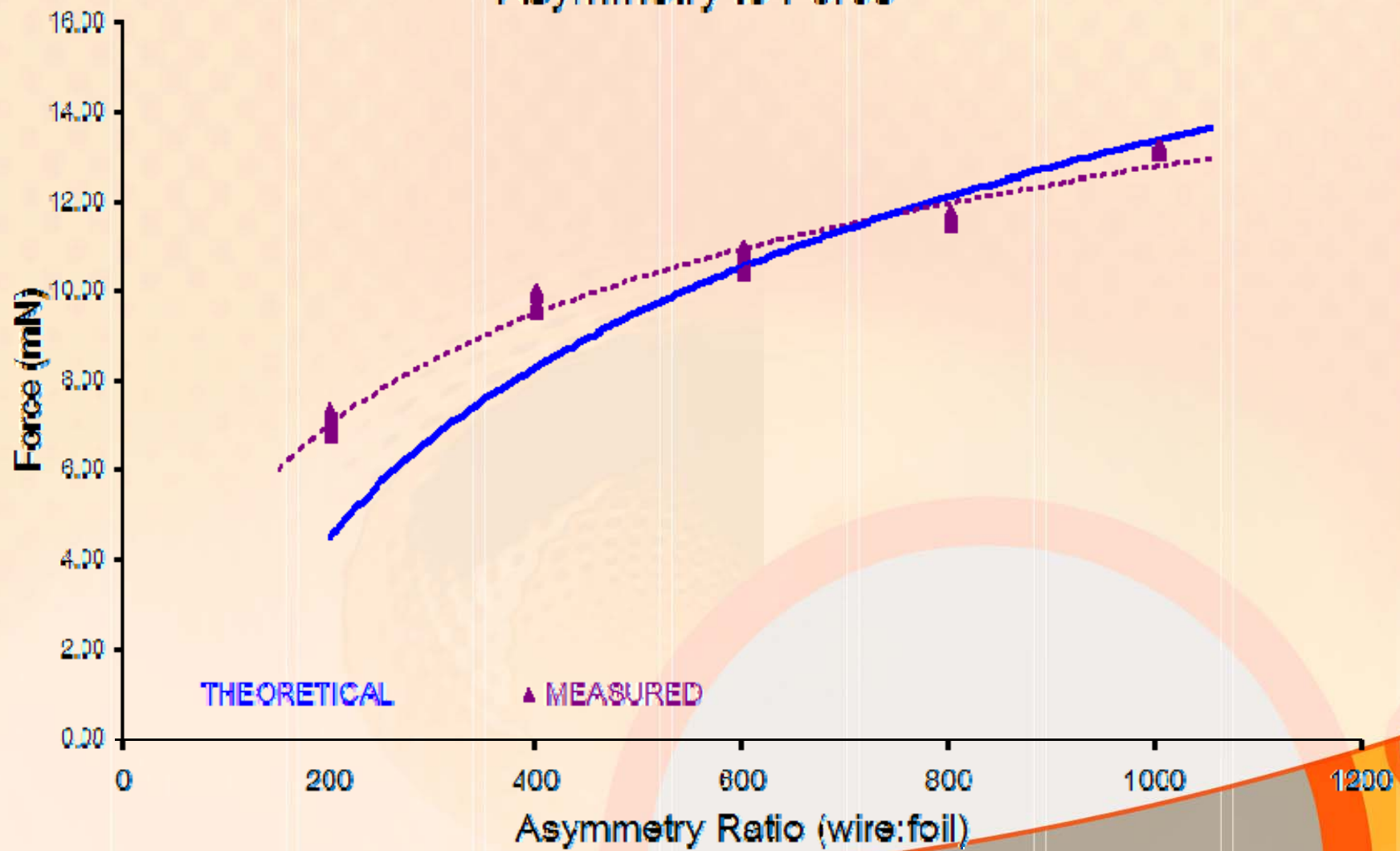
$$F = sGV(V - V_0)$$

$$F = I \frac{s}{k} = 2\pi\epsilon_0 VL \frac{V - r_w \delta E_0 \ln\left(\frac{s}{r_w}\right) \left(1 + \frac{0.301}{\sqrt{\delta r_w}}\right)}{s \ln\left(\frac{R_f \pi \cdot e^{\frac{2\pi}{R_f}}}{r_w}\right)}$$

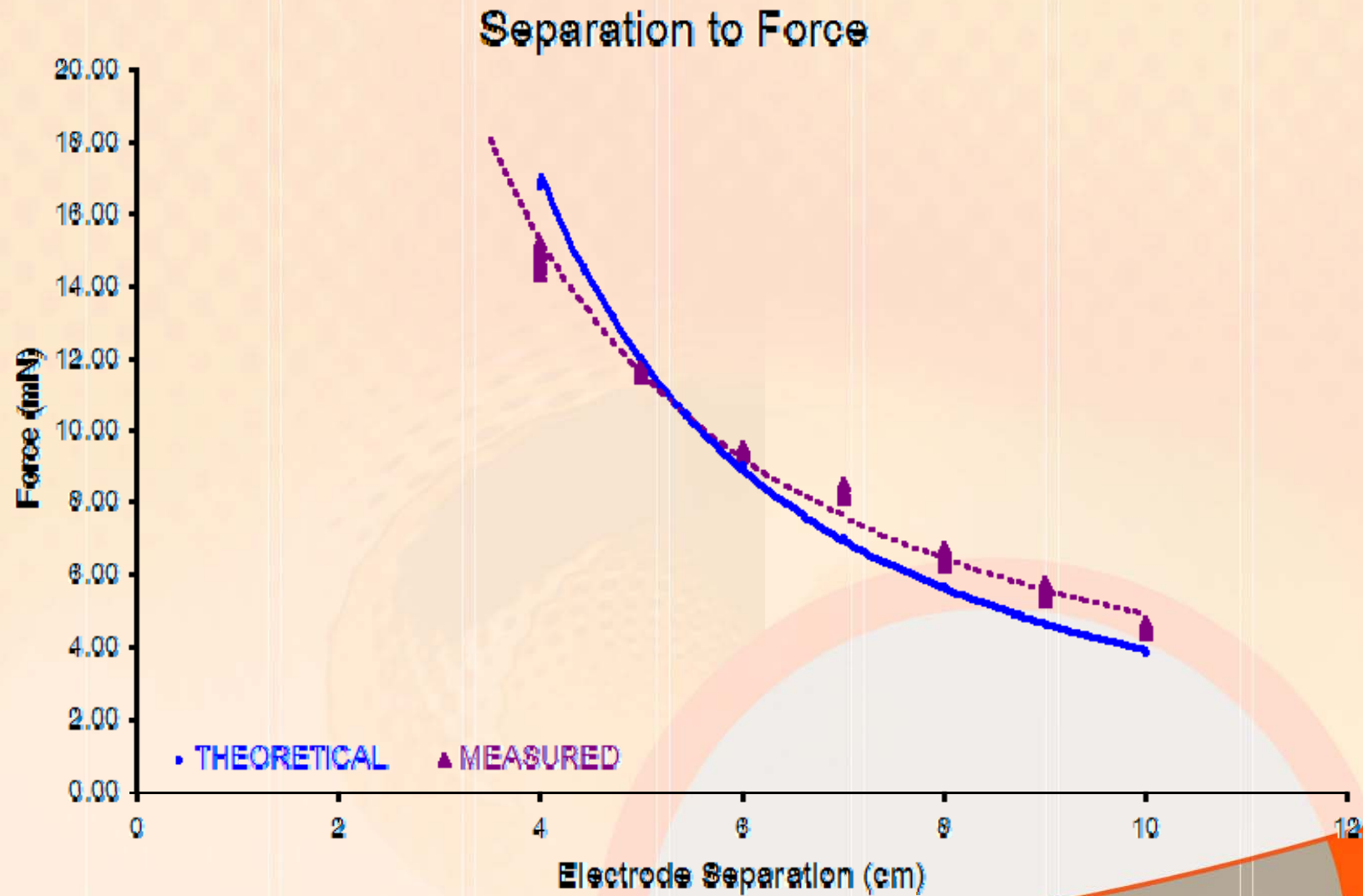
ASYMMETRY

THEORETICAL

Asymmetry to Force



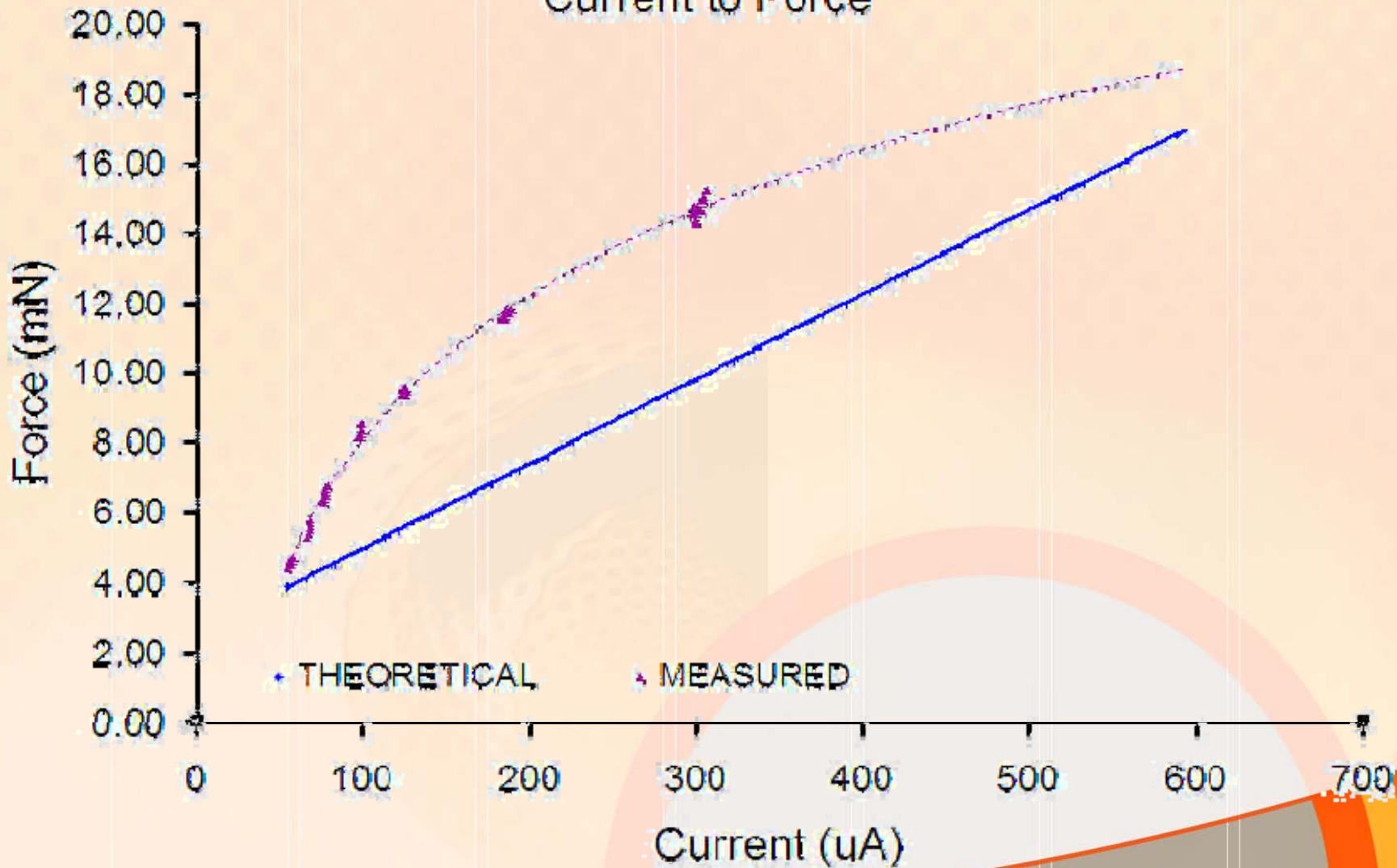
ELECTRODE SEPERATION



CURRENT FLOW

THEORETICAL

Current to Force



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CURRENT FLOW MATHEMATICS

Theory assumed only one ionizing electrode

Ion pockets on foil electrode not accounted for—subtract from force

$$f(i) = \sum f_n(i) = f_w(i) + f_f(i)$$

Total force is sum of flow from wire and foil

$$f_f(i) = \phi(i)(i - \xi)$$

Flow from foil is percentage of total flow times the increase in current from initiation

$$f(i) = f_w(i) - \sum_1^P \phi(n)(i - \xi)$$

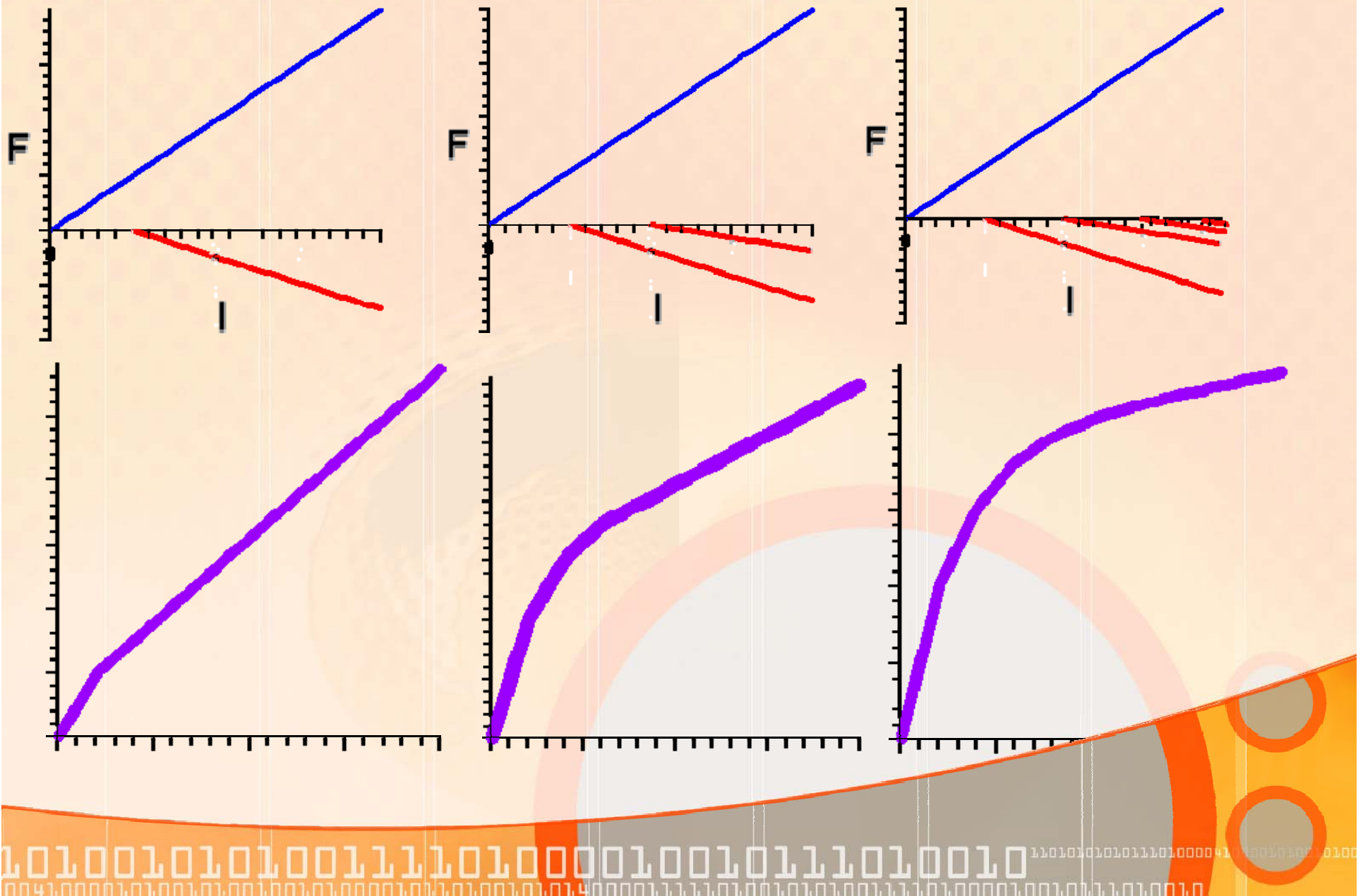
Total force is magnitude of wire force minus magnitude of foil force.

$$f(i) = \begin{cases} 0 & V < V_w \\ I \frac{s}{k} & V \geq V_w \end{cases} - \begin{cases} 0 & V < V_f \\ \sum_1^P \phi(n) \left(I \frac{s}{k} - \xi \circ V_f \right) & V \geq V_f \end{cases}$$

The revised force equation takes into account counter-current from the foil electrode



CURRENT FLOW MATHEMATICS



POTENTIAL APPLICATIONS



- Atmosphere as sole propulsive medium
- No onboard propellant
- No moving parts
- Silent

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CONCLUSION

- Thrust dependent primarily on the current applied
- Polarity was not a major factor in thrust magnitude or direction
- Results of experimentation pointed towards an ionic model for thrust

