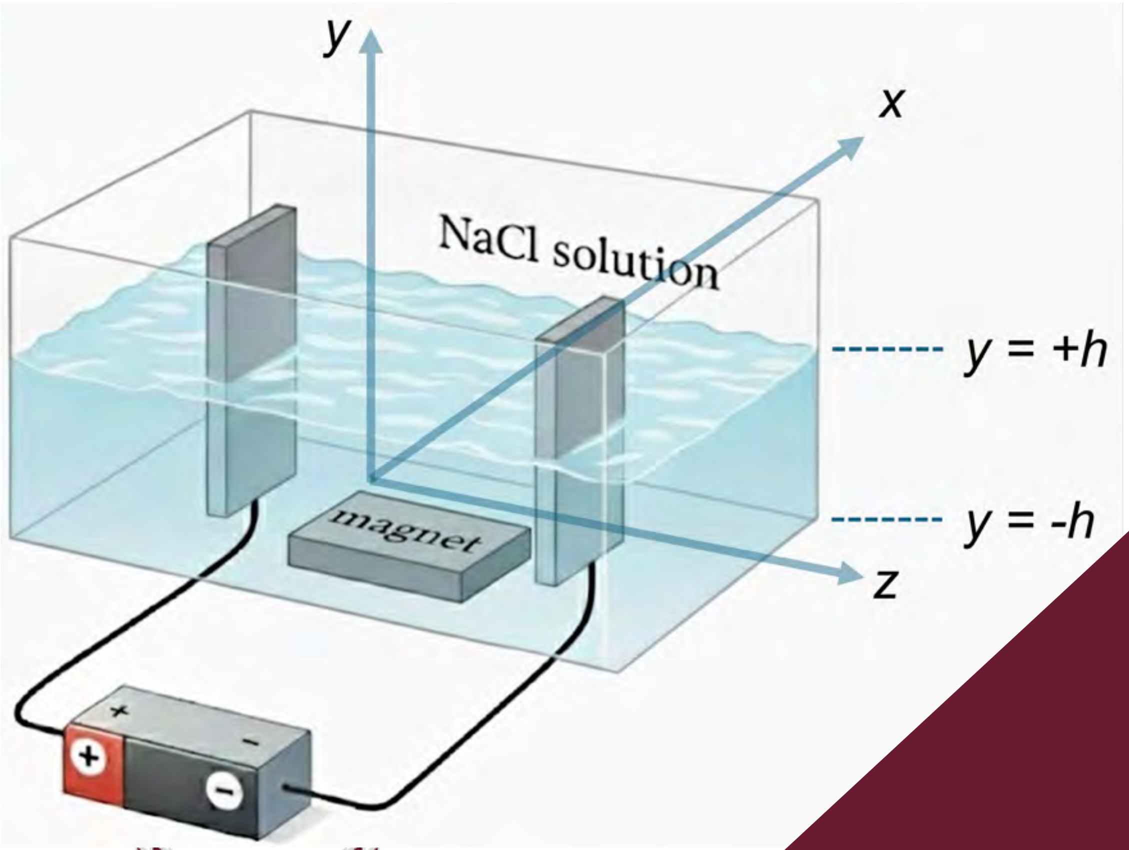
A table-top demonstration of magnetohydrodynamic flow



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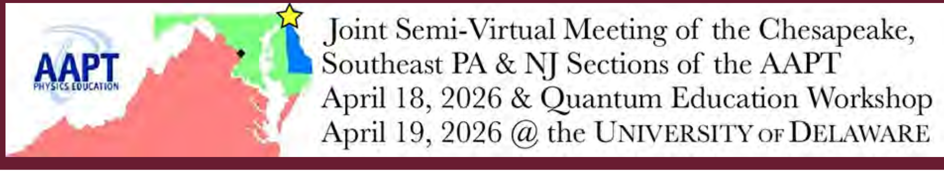

A table-top demonstration of magnetohydrodynamic flow

- What is Magnetohydrodynamic (MHD) flow?

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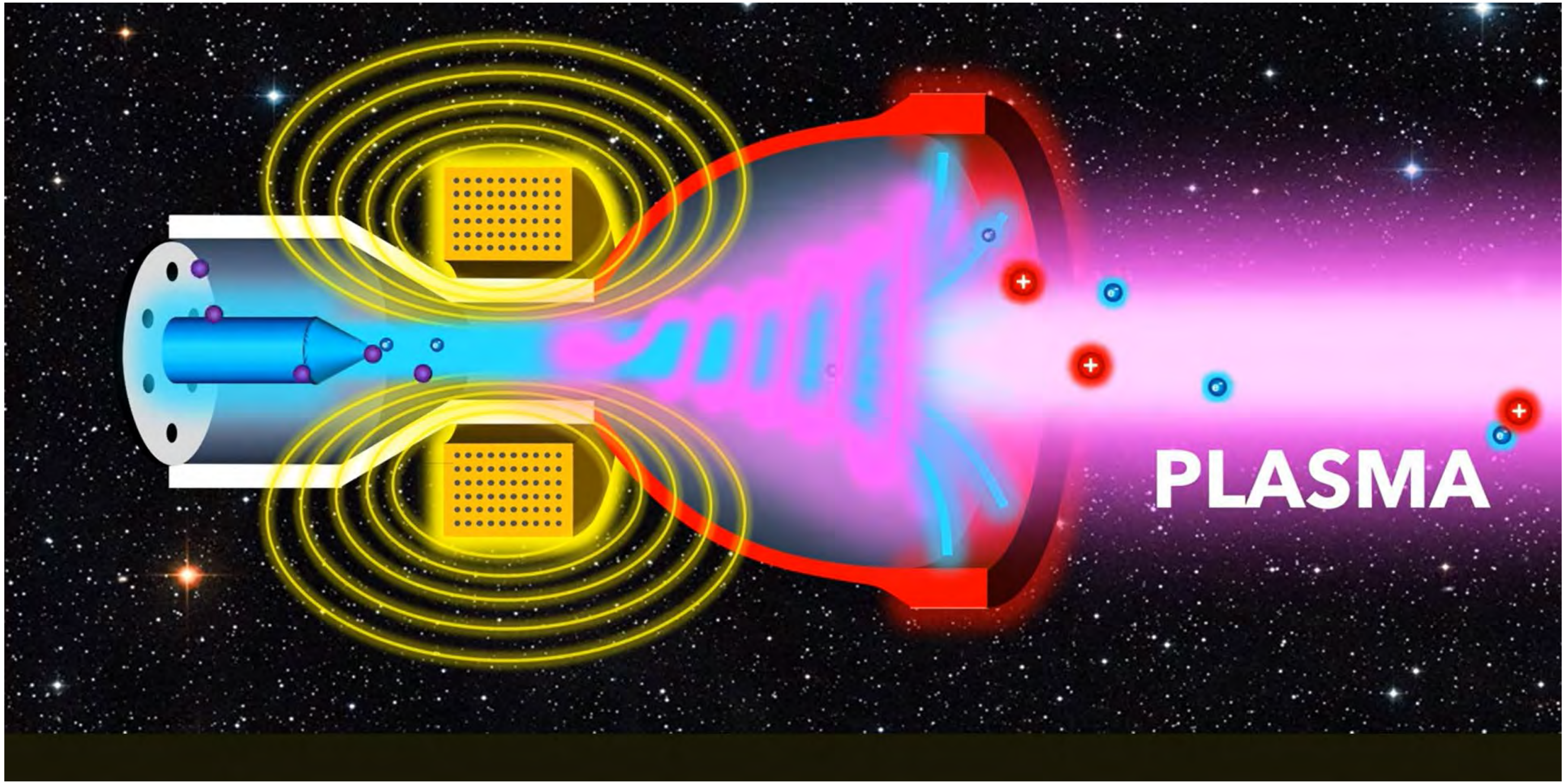
- What is Magnetohydrodynamic (MHD) flow?

Magnetohydrodynamic (MHD) flow, arises from the interaction between electric currents and magnetic fields in conducting fluids.

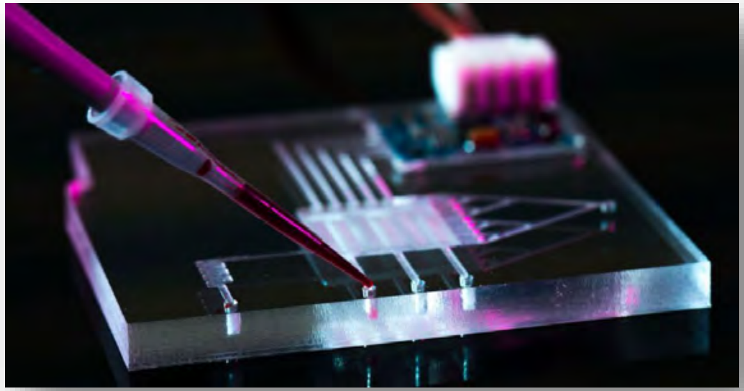
Applications of MHD flow

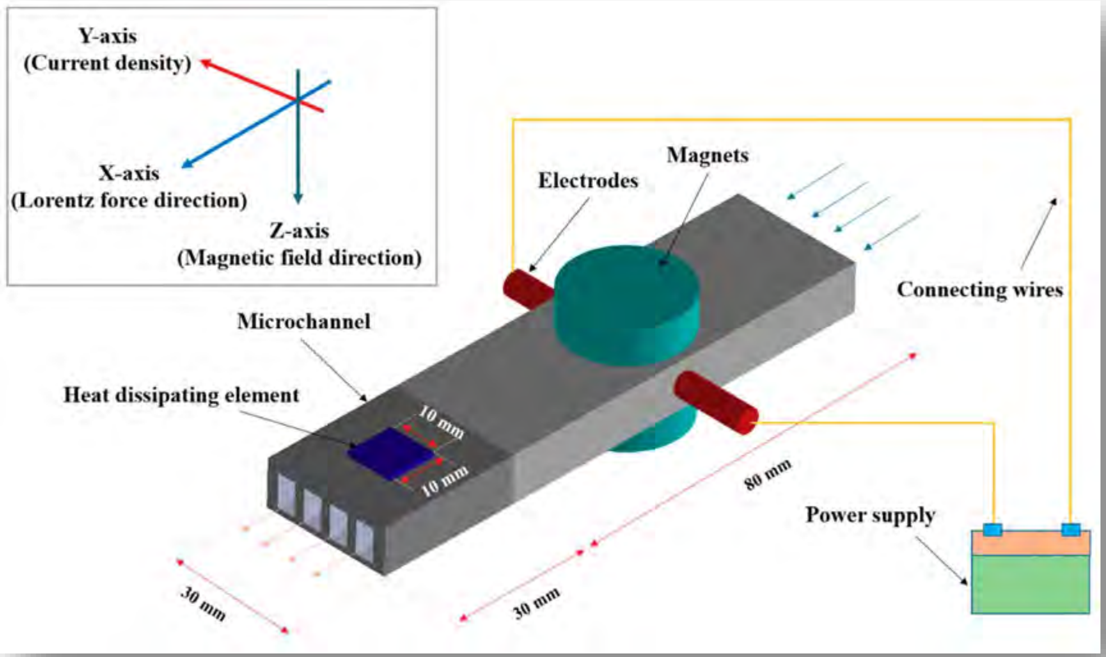
- Magnetoplasmadynamic (MPD) thrusters

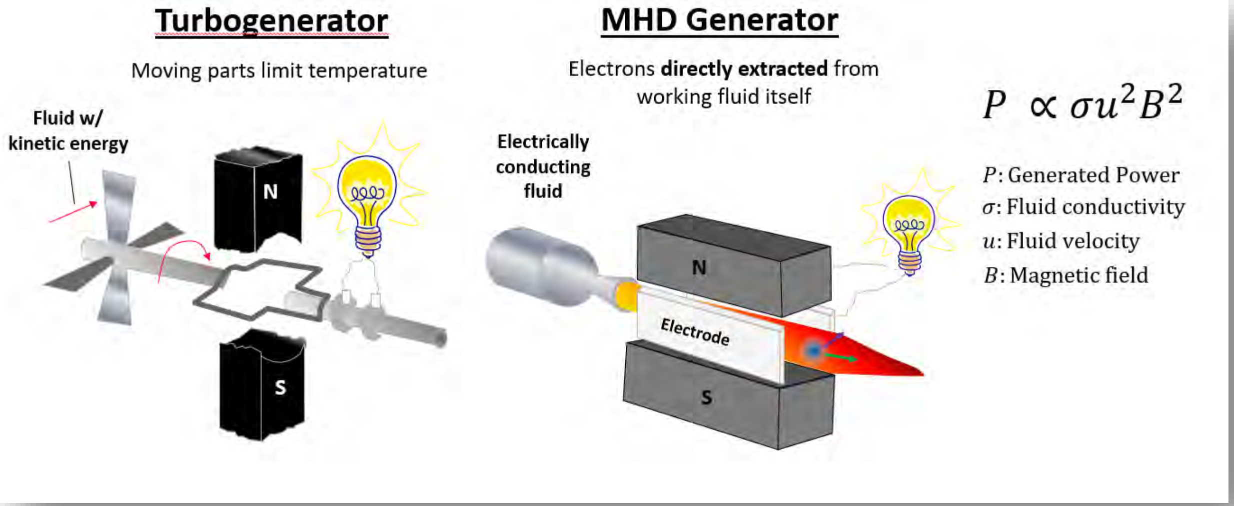


Applications of MHD flow

- Microfluidics and lab-on-chip systems
- Metallurgy and crystal growth
- Nuclear and fusion systems
- Power generation







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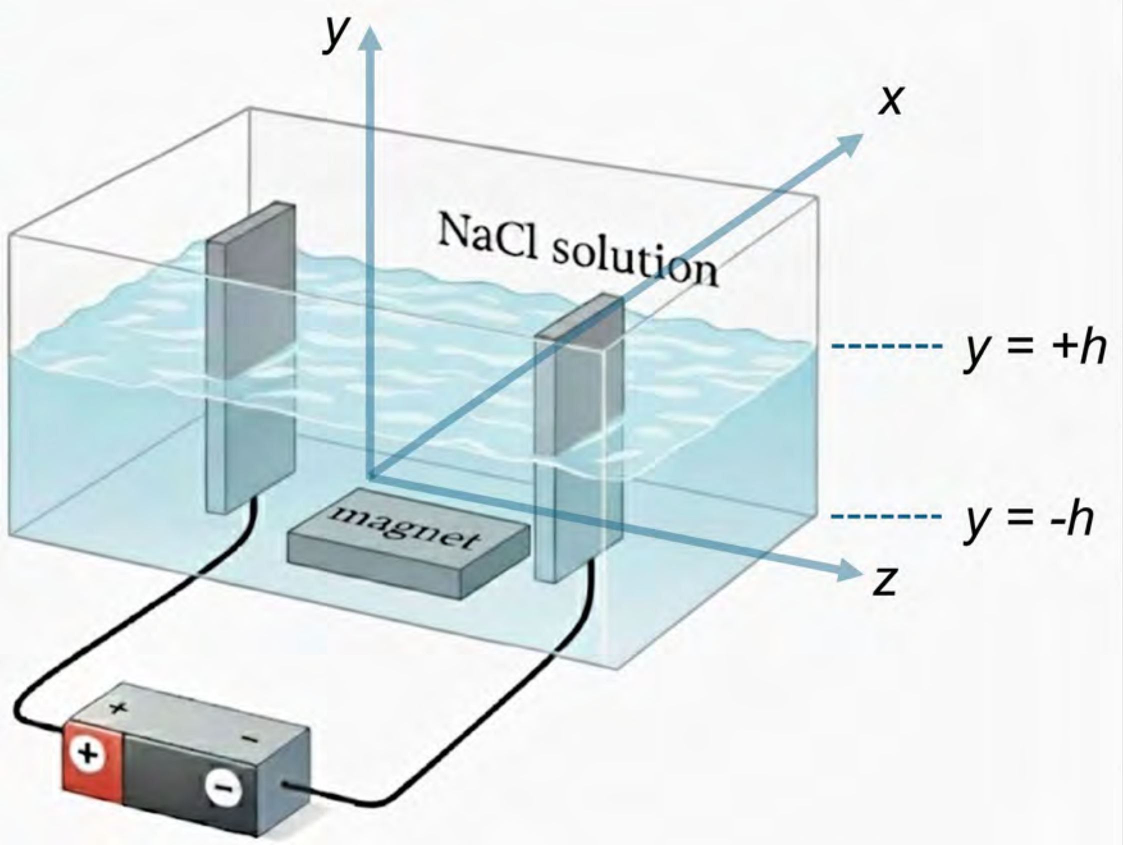
Defining the geometric coordinate space

To solve for the flow, we establish an orthonormal coordinate system. The base mean flow is purely streamwise and varies only with wall-normal position y, such that $\boldsymbol{U}(y) = U(y)\boldsymbol{e}_x$.



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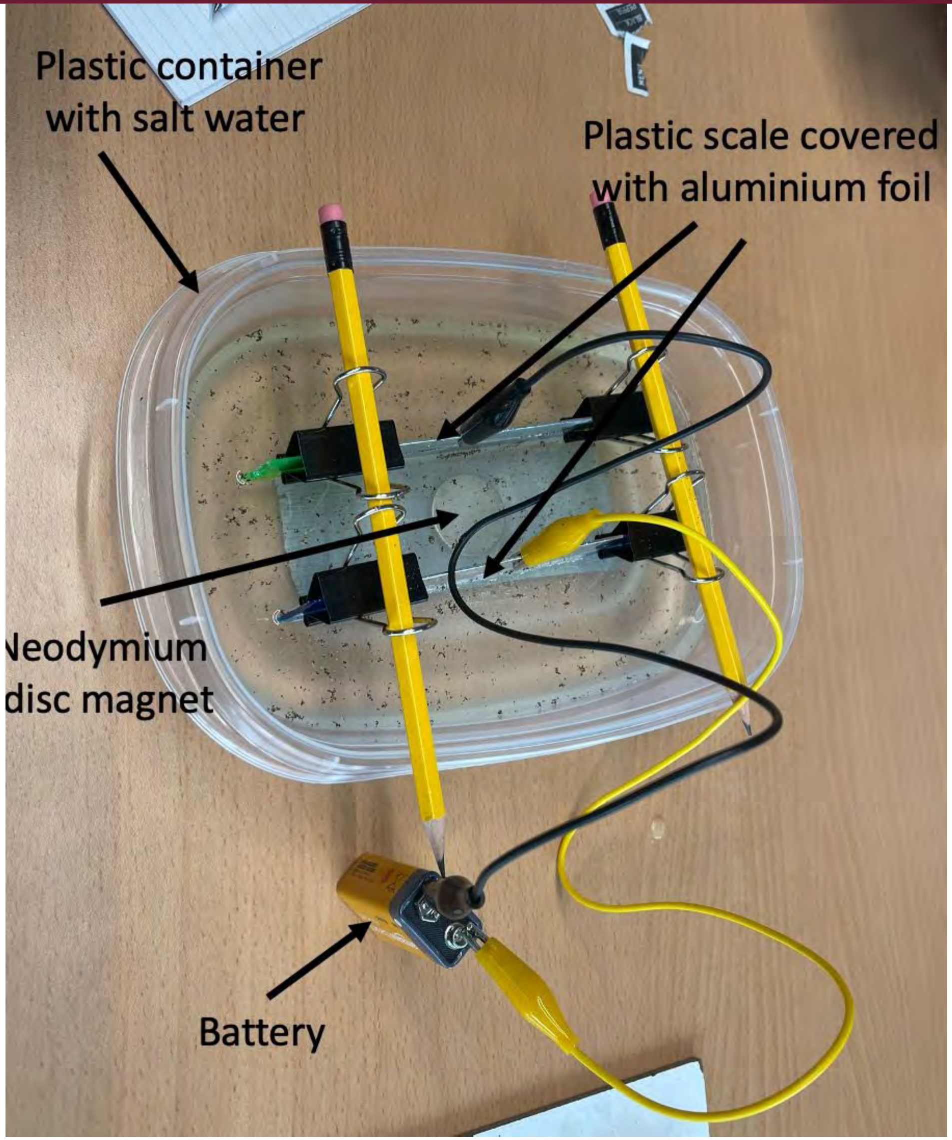

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The boundary condition pivot

Why standard Hartmann flow theory fails to predict our experimental results.

Standard Closed Channel	Our Asymmetric Experiment
	
Lower Boundary: No-slip ($y = -h$) → $U(-h) = 0$	**Lower Boundary:** No-slip ($y = -h$) → $U(-h) = 0$
Upper Boundary: No-slip ($y = +h$) → $U(+h) = 0$	**Upper Boundary:** Stress-free / Open ($y = +h$). Zero viscous traction ($\tau_{xy} = \eta\, dU/dy = 0$). **Flow Constraint:** dU/dy at y=$+h = 0$

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Defining the boundary value problem

We seek to solve the differential equation for the velocity profile U(y):

Viscous Forces

Magnetic Dampening/Drive

$$\eta \frac{d^2U}{dy^2} - \sigma B_0^2 U - \sigma B_0 E_z = 0$$

Boundary Conditions

$U(-h) = 0$
(Bottom no-slip constraint)

dU/dy at $y=+h$ = 0
(Top stress-free constraint)

Key Parameters Defined

$U_E = -E_z/B_0$
(Electric drift speed)

$Ha = B_0 h \sqrt{\sigma/\eta}$
(Hartmann number)

Questions?

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