



August 22–August 28, 2016


Interns show off a summer of research at PPPL




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Director's Office to use X2484



PPPL
PRINCETON
PLASMA PHYSICS
LABORATORY




PRINCETON
UNIVERSITY

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¹ Princeton Plasma Phys


Abstract

It is believed that Magneto-Rotational Instability (MRI) is responsible for the transport of angular momentum in accretion disks. We ran simulations using the Spectral Finite Element Maxwell and Navier-Stokes (SFEMaNS) Simulations results are shown in a way that helps to understand the behavior of the radial and axial velocity of the flow in the MRI experiment along with the magnetic field induced; always taking in consideration that the device used in experiments does not completely resembles the mechanism of an accretion disk: the hollow container used to hold the liquid Gallium exerts other instabilities that we have to identify and sort out in order to recognize MRI. We analyze data for several time-steps changing different parameters, such as rotation speed, and induced magnetic field, in order to determine whether a steady state is reached, or whether there are fluctuations that can be measured.

BACKGROUND: Accretion Disks



Accretion: Accumulation of particles into a massive object by gravitationally attracting more matter



Accretion Disk: Material, such as gas, dust and other stellar debris that has come close to a black hole but not quite fallen into it, forms a flattened band of spinning matter around the event horizon

Spectral Finite Element
solve the Magneto-Rotational
domains and to compare res
experiments. In s
from the effect of

$$\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} = -\nabla \Pi$$
$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{u} \times \mathbf{B})$$
$$\nabla^2 \Psi = 0 \text{ in vacuum}$$

The code works with

$$Re = \frac{\Omega_1 R_1^2}{\nu} = \frac{400}{3 \times 10^{-6}}$$
$$Rm = \frac{\Omega_1 R_1^2}{\eta} = O(1)$$
$$B_0 = \frac{\tilde{B}_0}{\sqrt{\rho \mu_0 \Omega_1 R_1}} = \frac{5.96 \times 10^7 \text{ S}}{3.10 \times 10^6 \text{ S}} = 19.2$$

$\sigma_r = 1, \sigma_s = \frac{5.96 \times 10^7 \text{ S}}{3.10 \times 10^6 \text{ S}} = 19.2$

$d = \frac{2}{7}$

Time-step

===Time step
2.d-3, 3000

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3D PRINTER

- ❑ Makerbot Replicator 2 (PLA)

- ❑ TAZ LULZBOT (ABS)



WIRE

- ❑ Belden 8076 (dia: 1mm)
- ❑ Copper Magnet Wire

MODELS



Model 1

- ❑ 16 turns and PLA
- ❑ Two 2mm holes at the top (Entrance and Exit)
- ❑ Due to small hole diameter to wire diameter ratio it was difficult to feed the wire through.
- ❑ Modification: Create 4 layers each containing 4 turns to reduce the friction experienced between the wire and plastic (PLA and ABS).

- ❑ The entrance and exit was now oriented to the side of the cylinder.
- ❑ The two 2mm holes increased to 5mm.
- ❑ Layers were connected by two nut and bolt connections.
- ❑ Still difficult to coil due to the continuous contact between the plastic and wire.



Model 6



- ❑ 64 turns
- ❑ 2mm diameter (entrance and exit)
- ❑ Horizontal slits added to reduce contact between the wire and the plastic structure.

Model 7a

CHALLENGES

- ❑ The printing bed's area restricted the size of model that was initially printed.
- ❑ Printer malfunctions or running out of filament slowed the design and testing process.
- ❑ Resolution of print affected the quality of the channels within the model being printed as well as print time.

MAGNETIC PROPERTIES

Table 1: Magnetic field generated from Model 7b (64 turns ~ 25m)

Voltage [V]	Current [A]	Magnetic Field Strength* [G]
1	0.72	1.2
2	1.38	3.2
3	2.20	5.4

*The magnetic field is measured at the axis.
Calculated R = 0.7 ohms

CONCLUSION

- ❑ Additive manufacturing allows for intricate designs which are needed in modelling stellarator coil geometries.
- ❑ This designs allows a wire to be uniformly coiled in the shape that's printed.
- ❑ There is also space for a lubrication or cooling system to be added.

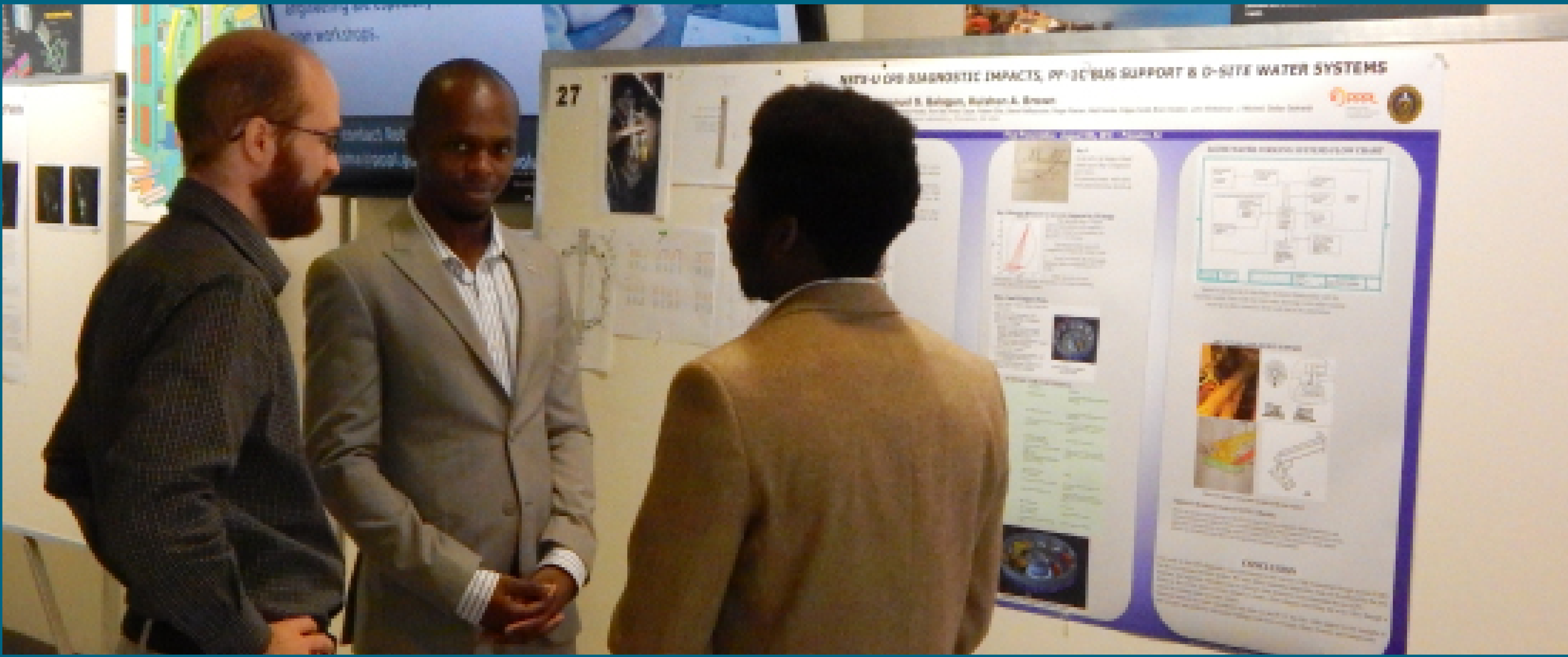
FUTURE STEPS

- ❑ To design "building blocks" style models that would allow the user to manipulate the diameter of the turns as well as the intricacy of the shape to emulate a stellarator like W7X.
- ❑ To add a cooling system to the current design and possibly a lubrication system to the channels to increase the field strength.
- ❑ Implement these designs to construct a portable stellarator.

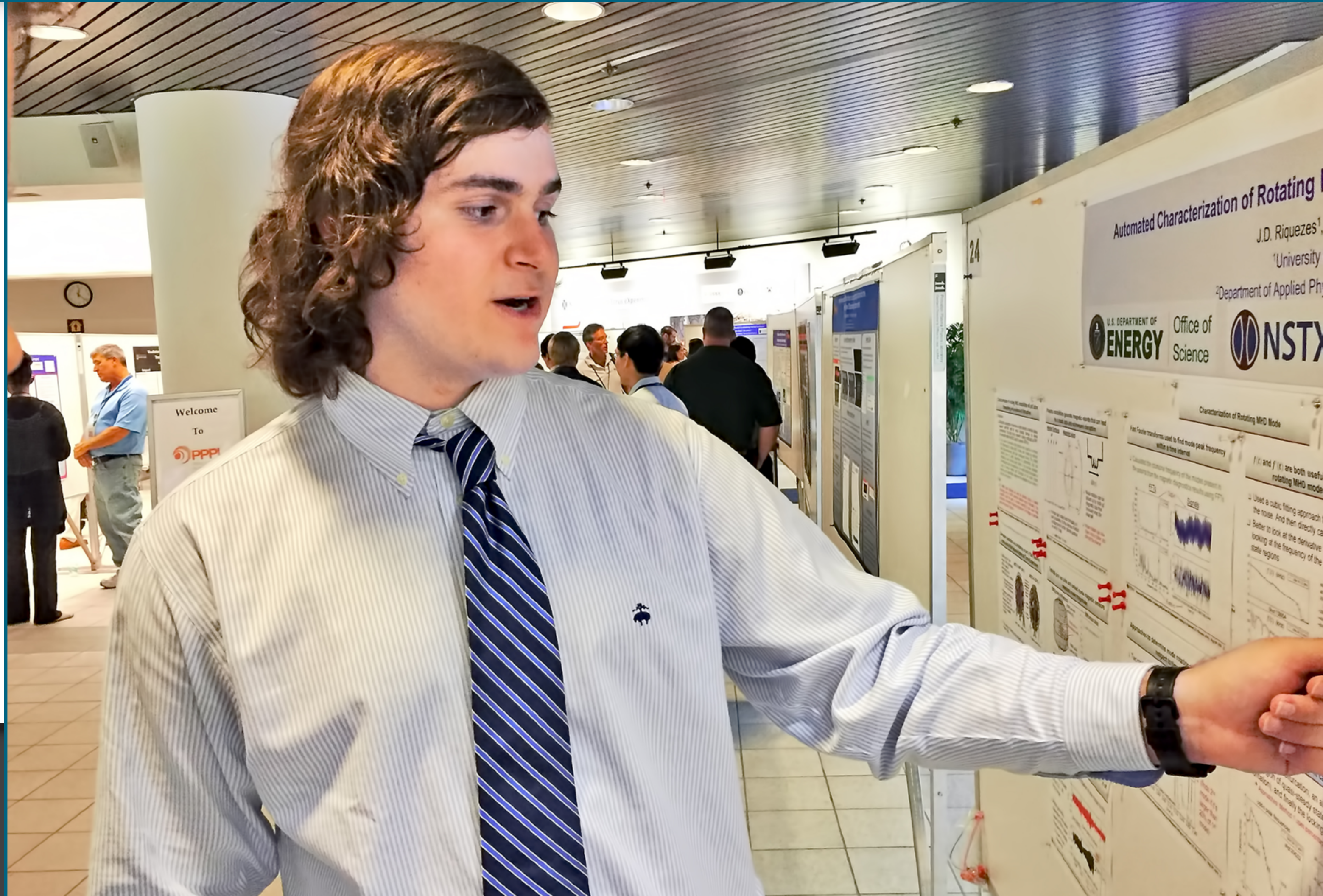
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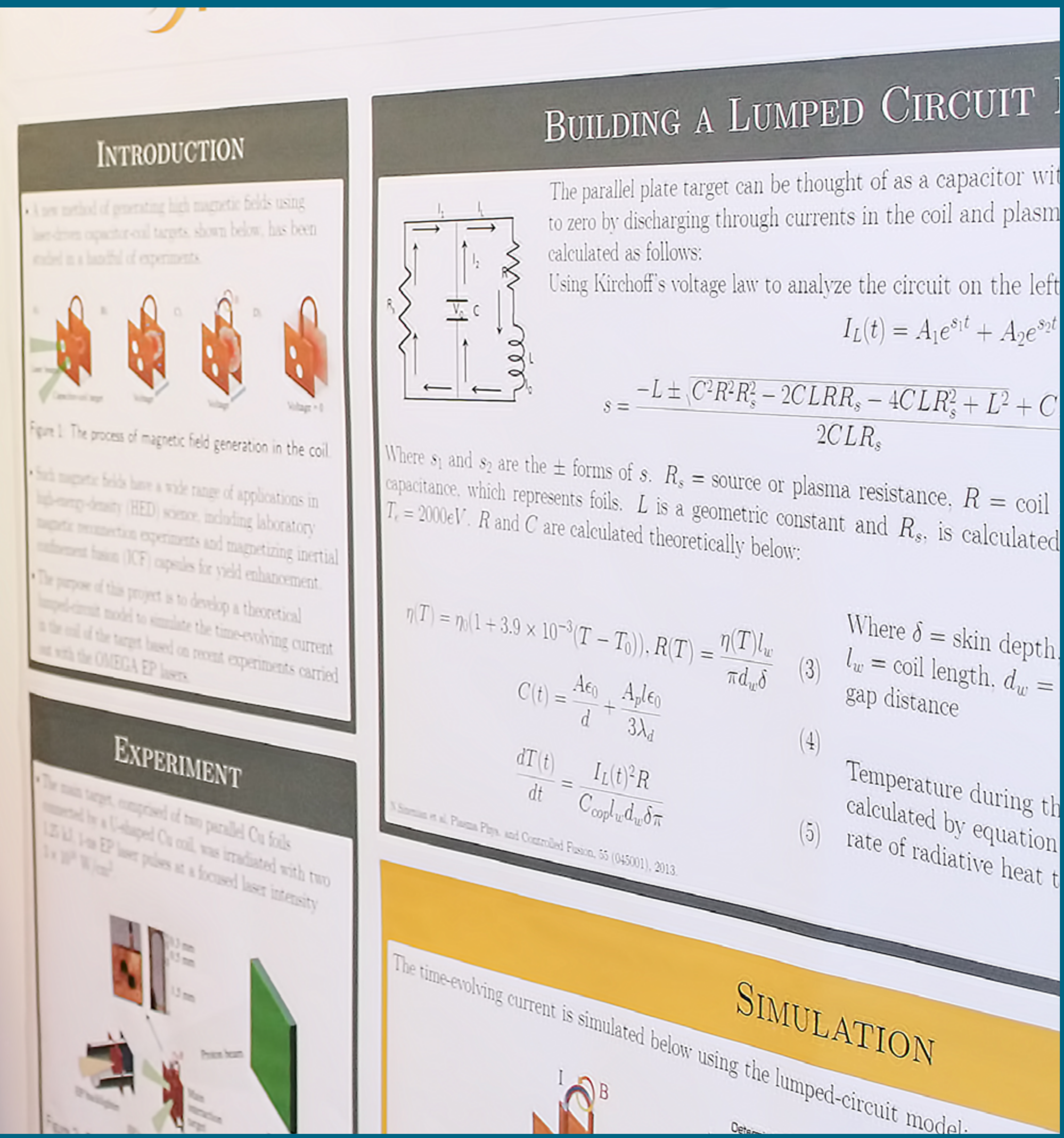
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INTRODUCTION

A new method of generating high magnetic fields using laser-driven capacitor-coil targets, shown below, has been modeled in a handful of experiments.

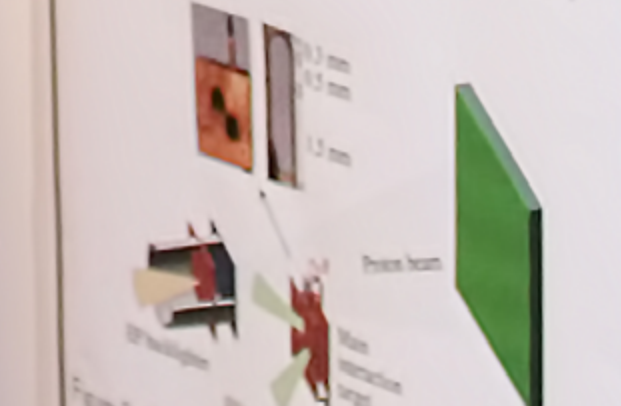


Figure 1: The process of magnetic field generation in the coil.

- Such magnetic fields have a wide range of applications in high-energy-density (HED) science, including laboratory magnetic reconnection experiments and magnetizing inertial confinement fusion (ICF) capsules for yield enhancement.
- The purpose of this project is to develop a theoretical lumped-circuit model to simulate the time-evolving current in the coil of the target based on recent experiments carried out with the OMEGA EP lasers.

EXPERIMENT

The main target, comprised of two parallel Cu foils connected by a U-shaped Cu coil, was irradiated with two 1.25 kJ, 1-ns EP laser pulses at a focused laser intensity of 3×10^{14} W/cm².



BUILDING A LUMPED CIRCUIT

The parallel plate target can be thought of as a capacitor with zero by discharging through currents in the coil and plasma calculated as follows:

Using Kirchoff's voltage law to analyze the circuit on the left

$$I_L(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$$
$$s = \frac{-L \pm \sqrt{C^2 R^2 R_s^2 - 2CLRR_s - 4CLR_s^2 + L^2 + C}}{2CLR_s}$$

Where s_1 and s_2 are the \pm forms of s . R_s = source or plasma resistance, R = coil capacitance, which represents foils. L is a geometric constant and R_s is calculated $T_e = 2000$ eV. R and C are calculated theoretically below:

$$\eta(T) = \eta_0(1 + 3.9 \times 10^{-3}(T - T_0)), R(T) = \frac{\eta(T)l_w}{\pi d_w \delta} \quad (3)$$

$$C(t) = \frac{A\epsilon_0}{d} + \frac{A_p\epsilon_0}{3\lambda_d} \quad (4)$$

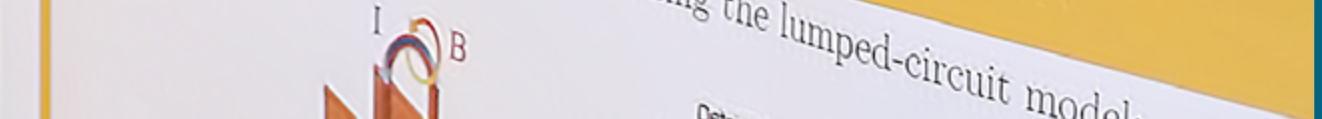
$$\frac{dT(t)}{dt} = \frac{I_L(t)^2 R}{C_{cool} l_w d_w \delta \pi} \quad (5)$$

Where δ = skin depth, l_w = coil length, d_w = gap distance

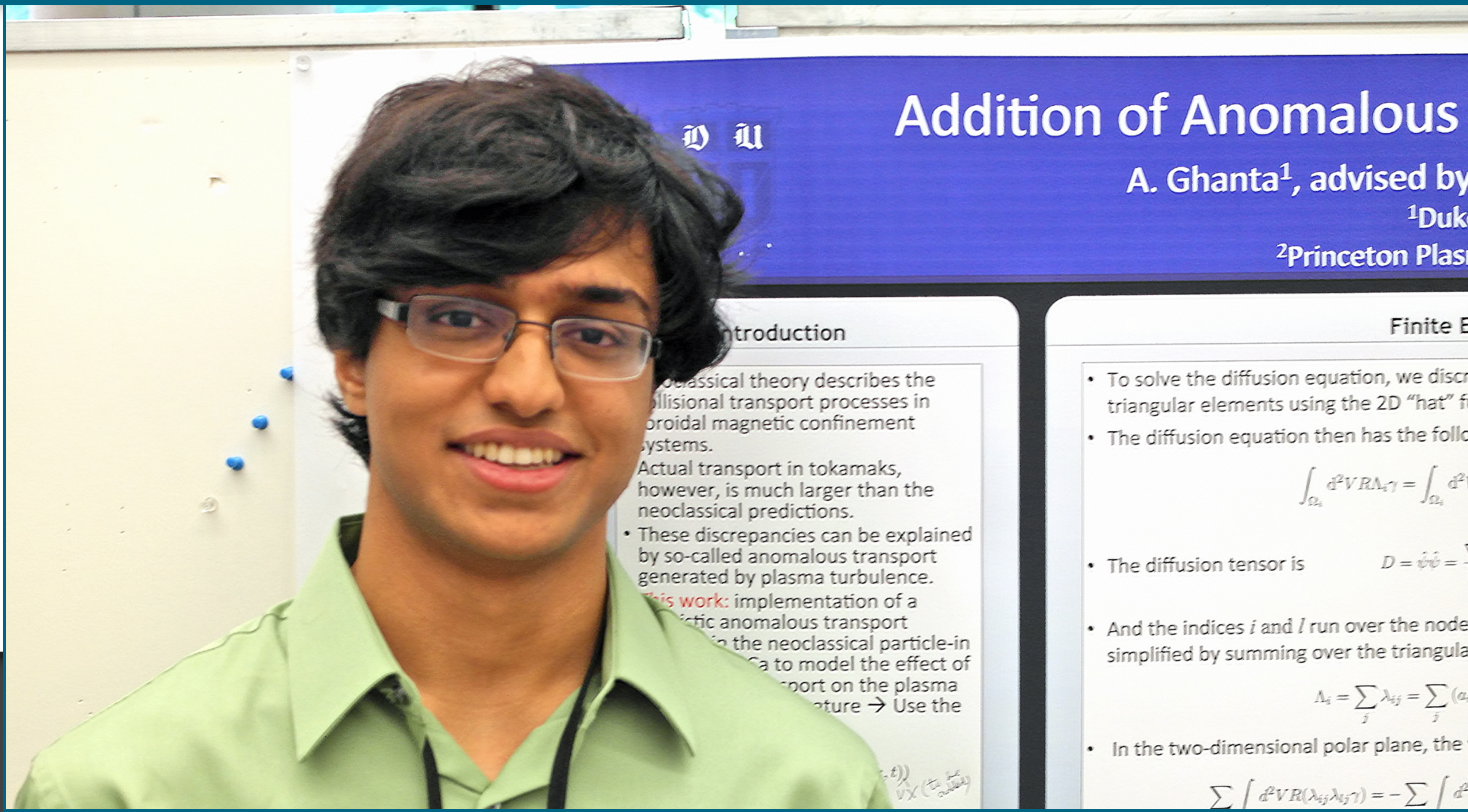
Temperature during the experiment is calculated by equation (5) rate of radiative heat transfer

The time-evolving current is simulated below using the lumped-circuit model:

SIMULATION



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Submissions wanted for art exhibit on “The Art of Discovery”

The West Windsor Arts Council is seeking submissions from scientists and artists for an exhibit on “The Art of Discovery.”

The deadline is Aug. 21. Details are available at the Arts Council website. Andrew Zwicker, head of PPPL’s Science Education, will judge submissions. The exhibit will be Sept. 12 to Oct. 29 at the West Windsor Arts Center in Princeton Junction.

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Yoga Classes

PPPL offers lunchtime yoga classes each Monday and Wednesday from noon to 1 p.m. in the LSB Commons.

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Get involved!

Tour Guides and Hosts Wanted!

We need engineers and physicists who are willing to donate a couple of hours of their time each week to show off the cool science at the Laboratory. We are also looking for hosts to greet visitors and make sure tours begin smoothly.

Please email Jeanne Jackson DeVoe, jjackson@pppl.gov to volunteer.

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September 24th Bluefishing Trip

Aboard the Suzie Girl

Date: Saturday September 24th 2016

Departure: 7:30 a.m. SHARP!!!

Location: Belmar Marina Hwy. 35, Belmar, NJ 07719

Cost: \$80 Per person ALL INCLUSIVE

Cost includes everything: rods, bait, fish cleaning, food, beverages. All you need to do is show up!

Money due by Friday, September 16th. NO REFUNDS.

Contact Andy Carpe, ext. 2118, acarpe@pppl.gov,
or Bob Tucker Jr., ext. 3190, rltucker@pppl.gov

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October Boy Scouts STEM Fair

Volunteers needed

Subject experts in physics and engineering are especially needed to plan workshops.



Please contact Rob Sheneman,
rshenema@pppl.gov, ext. 3392, to volunteer.

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BROCK

MARK GAZO

Chef Manager

Premier



BREAKFAST 7 a.m. • 10 a.m.

CONTINENTAL BREAKFAST 10 a.m. • 11:30 a.m.

LUNCH 11:30 a.m. • 1:30 p.m.

SNACK SERVICE until 2:30 p.m.

	Monday August 22	Tuesday August 23	Wednesday August 24	Thursday August 25	Friday August 26
COMMAND PERFORMANCE Chef’s Feature	Zesty Orange Chicken & Broccoli over Rice	Vegetarian Chili over Rice with Cornbread	CREATE YOUR OWN Burrito Bar	Baked Macaroni with Ham served with Stewed Tomatoes	OUTDOOR BBQ Hamburgers, Hot Dogs, Chicken, Beans, Corn, Coleslaw, Watermelon, Beverage
Early Riser	Breakfast Club Sandwich	Greek Egg White Omelet with Spinach, Tomato, Peppers & Feta Cheese	Breakfast Pizza with Ham, Bacon & Sausage	Omelet Florentine with Spinach, Tomato & Mozzarella	Breakfast Tacos
Country Kettle	Mushroom Barley Kielbasa	Pasta Fagioli	Chicken & Quinoa	Tomato Spinach Lentil	Seafood Bisque
Grille Special	Colossal Burger with 2-5.3 oz patties, American Cheese, Lettuce, Tomato & Onion	Pepperoni Pizza Steak Sandwich with Fries	Tuna Melt on Rye served with Onion Rings	Taco Dogs	Spinach Salad with Turkey Bacon, Hard-Cooked Egg, Mushrooms & Raspberry Vinaigrette
Deli Special	Stacked Veggie Sandwich with Guacamole	French Dip with Swiss Cheese, Caramelized Onion & Horseradish Cream served with Potato Wedges	Prosciutto, Pesto, Roasted Peppers & Arugula on Ciabatta	Krabby Kake on a Kaiser with Lettuce & Tomato	Buffalo Chicken Wings with Blue Cheese, Fries & Celery
Panini	The Cubano	Popcorn Chicken & Mashed Potato Bowl topped with Seasoned Corn & Country Gravy	Southwest Turkey, Peppers & Cheddar with Jalapeño Ranch Spread	Tomato & Fresh Mozzarella on Ciabatta with Basil, Red Onion & Arugula	Turkey French Dip with Swiss Cheese

MENU SUBJECT TO CHANGE WITHOUT NOTICE

VEGETARIAN OPTION

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