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Michigan Institute for Plasma Science and Engineering

Joint MIPSE/Aerospace Seminar

Monday
August 11, 2025
1:30 pm
Room 1003 EECS

Dr. Michael McDonald

U.S. Naval Research Laboratory (NRL)

Intro to DARPA 101 + Challenges in Plasma and Machine Learning

This talk begins with understanding DARPA (Defense Advanced Research Projects Agency) as a sponsor, to help you work with the agency better. DARPA appears a monolith but internally has several offices each with a unique focus. Each office is staffed by an ever-shifting blend of Program Managers (PMs) with unique priorities. Offices and PMs are united only by a mission to cultivate radically "new things under the sun" to generate scientific surprise. We will explain features of the offices, the program managers, and what a good pitch to a DARPA PM looks like. The second half of this talk will pose example "DARPA-hard" questions in plasma science, engineering, and related aspects of machine learning (ML). Why don't plasma physicists have a tool to tell us the plasma state at a glance, like DeepMind's AlphaFold for protein folding in biology? Why is it so devilishly hard to get an accurate, repeatable measure of plasma density, even in simple plasma? When it comes to complex plasma chemistry, will we need to rely on AI/ML solutions? The central miracle of our age is that humans have developed machines to learn skills we cannot explicitly teach. How do we learn to learn from them? Are there ways to use ML applied to scientifically interesting problems to tease out a better understanding of physical laws? This talk will motivate these questions, but DARPA has no labs of its own, so bring your own solutions!

About the Speaker: Dr. Michael McDonald is an Aerospace Engineer in the Spacecraft Propulsion Section at the U.S. Naval Research Laboratory (NRL) in Washington DC, and will join DARPA as a Program Manager in the Defense Science Office in Fall 2025. He received his PhD from the University of Michigan in Applied Physics in 2011, and joined NRL in 2012. At NRL he founded and leads the Space Technology and Applications Research Lab (STARLab) specializing in the creation and characterization of energetic flows for a variety of national security space sponsors, including DARPA, USAF and USSF. The centerpiece of STARLab is the Large Plasma Test Facility (LPTF), a world-class vacuum chamber used for spacecraft propulsion and very low Earth orbit environmental simulation research. Dr. McDonald's research interests include hollow cathodes; electron emission physics; spacecraft plasma propulsion including Hall and MPD thrusters; and high-speed plasma diagnostic development. At DARPA he has many dreams including air-breathing cathodes for vLEO, rapid qualification methods for >100kW propulsion systems, standard candles for NIST-traceable plasma density diagnostics; AI self-learning methods for plasma state measurement and collisional-radiative model development, a la Google's AlphaFold; and development of scalable AI mechanistic interpretability techniques to untangle what neural networks learn in human-understandable terms.