



Wednesday
October 26, 2022
3:30 pm
Room 1005 Dow

Dr. Michael McDonald

U.S. Naval Research Laboratory (NRL)

Trying to Build Better Mousetraps: From Hollow Cathodes to a Plasma Density “Standard Candle”

In this talk we discuss work at the Naval Research Laboratory in the Spacecraft Engineering and Plasma Physics Divisions on hollow cathodes and time-resolved plasma diagnostics. We begin with development of the plasma impedance probe, or PIP. Langmuir probes measure plasma properties by sweeping a voltage across a plasma-wetted electrode and recording the collected current. The Langmuir probe is widely used, yet the accuracy of its density measurement often have error estimates of $\sim 10\text{-}20\%$, and often quote only statistical error. When asked how well that statistical cloud matches the truth, the goalposts might be moved to plus or minus a factor of two! While we use NIST-traceable standards for many quantities, there is sadly no standard plasma density “candle”. Meanwhile, in our development of thermionic hollow cathodes we see huge variance in estimates of anomalous electron transport “collision” frequencies due to assumptions we make to infer them from measurable plasma parameters. We will discuss ways to address both problems in the context of development of the PIP, a shift from Langmuir probes towards timing-based mechanisms to query the plasma frequency itself. We extended the PIP from a static low-density (10^6 cm^{-3}) diagnostic to $>100 \text{ kHz}$ measurement of plasma densities up to 10^{10} cm^{-3} , and begun work on tomographic inversion of plasma density within a PIP array. We describe our plans to generate a plasma density “standard candle” for absolute calibration of PIP density measurements, and discuss our first data directly querying the total effective electron collision frequency in a hollow cathode plasma.

About the Speaker: Dr. McDonald is an Aerospace Engineer in the Spacecraft Engineering Division at the U.S. Naval Research Laboratory (NRL). He received his PhD from the U. of Michigan in Applied Physics in 2011, and joined NRL in 2012. NRL is home to several hundred MS and PhD scientists and engineers focusing on space science, engineering and plasma physics, and Dr. McDonald leads a research group in the Spacecraft Propulsion section, working closely with NRL’s Plasma Physics Division. His research interests include hollow cathodes (thermionic and RF-based) electron emission physics; propulsion technologies including Hall, gridded ion, ECR and MPD thrusters; plasma diagnostic development with a focus on high-speed measurements; and application of plasma sources to hypersonic environment simulation. In addition to supporting several full time staff working in these areas, Dr. McDonald is committed to mentoring the next generation of researchers by hosting undergraduate and graduate level summer interns and 1-2 postdocs at NRL each year. Please contact him at michael.mcdonald@nrl.navy.mil if you are interested!