

## Nuclear Engineering Seminar

### Dr. Allen Garner,

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**Wednesday, March 26, 2025**

**3:30 pm | FRNY G140**

Reenvisioning Space-Charge-Limited Current and Electron Emission

#### Abstract

The space-charge limited current (SCLC) is an important limit in high-power microwaves, vacuum electronics, directed energy, and sheath physics in the semiconductor industry. While the SCLC was derived over a century ago for a one-dimensional (1D) planar diode in vacuum, extensions to more general geometries have been challenging. This problem is exacerbated when considering devices that may not be operated under space-charge limited and/or purely vacuum conditions.

This seminar introduces several techniques to address these issues. We demonstrate the utility of variational calculus (VC) to extremize the current in the gap, conformal mapping of the space-charge limited electric potential from planar to the geometry of interest, and point transformations to derive exact solutions for 1D geometries. We further derive a universal relationship between vacuum and space-charge limited potential that yields SCLC for multidimensional diodes with any geometry that depends on the diode's capacitance with no space-charge, which may be easily calculated analytically or through simulation. In the process, we elucidate the true meaning of "1D" in practical devices. Finally, we extend these approaches to collisional diodes to generalize SCLC and to predict the transitions between the SCLC and the source currents (e.g., field or thermal emission). Experimental implications and the comparison of these theories to particle-in-cell simulations will be discussed.



Dr. Allen L. Garner received the B.S. (with high honors) in nuclear engineering from the University of Illinois in 1996. He received an M.S.E. in nuclear engineering from the University of Michigan in 1997, an M.S. in electrical engineering from Old Dominion University in 2003, and a Ph.D. from the University of Michigan in 2006. From 2006 to 2012, he was an electromagnetic physicist at GE Global Research Center. He joined Purdue in 2012, where he is a Professor and Graduate Program Chair in Nuclear Engineering. He is also a Captain in the US Navy Reserves.

Prof. Garner received a National Defense Science and Engineering Graduate Fellowship. He has also received two Meritorious Service Medals, the Navy and Marine Corps Commendation Medal, and five Navy and Marine Corps Achievement Medals. He received the 2016 IEEE NPSS Early Achievement Award.