Seminar Title: Bioelectrics: Pulsed Power, Plasma, and Laser Induced Biological Phenomena and Applications

Time: 3:00-4:00 PM, Friday, Feb 26, 2016
Location: ECE 101

Speaker:
Allen L. Garner
Purdue University

Abstract:
Electromagnetism is well-established for sensors; however, one may also use intense electromagnetism, such as pulsed power, plasmas, and lasers, to alter biological and cellular function. Recent investigations have focused on using these modalities to induce multiscale changes in biological specimens for applications ranging from drug delivery to wound treatment. The most common and mature example is electroporation, in which microsecond to millisecond duration electric pulses (EPs) of a few kilovolts per centimeter in field strength are applied to a tissue or cell suspension to permeabilize cell membranes. This facilitates the delivery of normally impermeant molecules to enable multiple technologies, including sterilization, gene therapy, and electrochemotherapy. Intense submicrosecond EPs can additionally manipulate intracellular organelles and cellular function, such as platelet activation for wound healing. Depending upon wavelength, lasers may permeabilize a single cell by inducing phase changes in the cell membrane’s lipids or multiple cells by combining electroporation and localized temperature gradients. Plasmas may permeabilize cell membranes by reactive species bombarding the membrane, directly membrane electropermeabilization, or indirectly through charged species buildup of charged species at the cell membrane. This facilitates food or equipment decontamination.

In this talk, I will outline my group’s integration of analytic approaches, simulations, and experiments to elucidate these differences. First, I will briefly summarize the physics, biology, and application space for EP effects and outline the application of modeling to predict and elucidate the effects of various electric field profiles, including nanosecond and microsecond EPs, bipolar EPs, and AC fields, on membrane pore formation and cell membrane temperature gradients. I will then compare and contrast EP, plasma, and laser-induced effects to demonstrate the universality of electromagnetic effects and the unique features of each type.

Speaker Bio:
Dr. Allen Garner received his BS in nuclear engineering from the University of Illinois in 1996, MSE in nuclear engineering from the University of Michigan in 1997, MS in electrical engineering from Old Dominion University in 2003, and Ph.D. in nuclear engineering from the University of Michigan in 2006. From 1997 to 2003, he served on active duty in the U. S. Navy as a nuclear trained submarine officer, including tours as a division officer onboard the USS Pasadena (SSN 752) and Prospective Nuclear Engineering Officer instructor in Norfolk, VA. From 2006 to 2012, Dr. Garner was an electromagnetic physicist at GE Global Research Center in Niskayuna, NY, where he conducted computational work in electromagnetism, plasmas, and multiphysics and led multidisciplinary efforts in plasma medicine. Since August 2012, he has been an Assistant Professor in Nuclear Engineering at Purdue University and is the Paul C. Zmola Scholar of Nuclear Engineering. He is also a Commander in the United States Navy Reserves presently assigned as the Commanding Officer for the Gulf Region of SurgeMain, which provides qualified technicians to support the Navy’s Public Shipyards. Dr. Garner is a Senior Member of IEEE and has been awarded the Navy and Marine Corps Commendation Medal and five Navy and Marine Corps Achievement Medals.