PURDUE UNIVERSITY | School of Nuclear Engineering

Nuclear Engineering Seminar

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3:30pm | Webex

Computational modeling of the mechanical response of brain tissue following exposure to pulsed microwaves

Abstract

With the development of directed energy weapons (DEWs) such as high energy lasers and high-power microwave (HPM) weapons, there is a growing concern regarding the unknown biological effects that result from directed energy exposure. In this study, we create a multiphysics computational framework to model HPM exposure (~1 GHz) and the resulting thermomechanical expansion of brain tissue. A finite-difference time domain (FDTD) approach is used to calculate the specific absorption rate (SAR) in a human head geometry resulting from transient exposure to a pulsed-modulated microwave field. The SAR values provide a 3D temperature field that is subsequently used as input into a finite element model (FEM) in order to observe the effects of thermomechanical expansion of brain tissue. A computational model is used to examine the influence of various temperature gradients and pulse durations on the mechanical response of brain tissue, which can result in the microwave auditory effect (MAE) and perhaps even injury (given large incident power densities). We show that a stress-focusing effect due to any sufficiently rapid temperature increase can result in the formation of stress waves and brain tissue strains that are larger than the initially applied thermal strains.

Dr. Amy Dagro is a Biomedical Engineer at the U.S. Army Research Lab (ARL) in Aberdeen Proving Ground, MD. She holds a B.S. in Biomedical Engineering from Johns Hopkins University (2009), a M.S. in Mechanical Engineering from Columbia University (2010), and. PhD in Mechanical Engineering from Johns Hopkins University (2019). She began working at ARL in 2010, in the research area of computational modeling of blast and ballistic effects on the human head. From 2014 -2019 she received the DoD "SMART" Scholarship to pursue PhD work in experimental techniques measuring the mechanical characterization of brain cells. Her recent work involves studying directed energy (DE) bioeffects on the human body, with a focus on thermoelastic stress waves in the human brain.