NEURAL ENGINEERING SEMINAR SERIES

Mathematical Models of Anomoalus Diffusion Processes in Brain

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ABSTRACT: The complexity of brain structure and processes suggests that anomalous diffusion of ions, water and other particles is involved in brain's functions and pathology. Anomalous diffusion through various materials has been successfully modeled using fractional calculus, and, therefore, in this talk, two mathematical models that use fractional order integro-differential operators will be presented: 1) a spatio-temporal fractional cable equation for action potentials propagation in myelinated neurons, and 2) a space-fractional reaction-diffusion equation for cerebral nitric oxide (NO) biotransport. While ionic anomalous diffusion near the nodes of Ranvier could be caused by the crowdedness of the very narrow ion channels and the diffusion barriers of the extracellular space, the anomalous diffusion of NO is due to its entrapment by endothelial microparticles whose production is enhanced in the presence of pathology. In addition, the model of NO biotransport incorporates the shear-induced NO production at endothelium and the pulsatile blood flow. The predictive abilities of the proposed models are investigated through numerical simulations.

BIOGRAPHY: Drapaca is an applied mathematician who got her BS and MS from University of Bucharest, Romania and her PhD from University of Waterloo, Canada. She has held postdoctoral positions at University of California in San Francisco and Mayo Clinic. Since 2007, Drapaca has been a faculty member in the Department of Engineering Science and Mechanics at Pennsylvania State University. Drapaca's expertise is in mathematical modeling of brain multiphysics and multiscale entangled processes, continuum and fluid mechanics, medical image processing, and computational analysis. The focus of her research is understanding mechanisms of onset and evolution of brain diseases through mathematical models and numerical simulations.