

PhD Dissertation Defense Announcement  
Mechanical and Aerospace Engineering Department  
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A MULTISCALE STUDY OF CAVITATION MECHANISM  
AND DAMAGE IN SOFT MATERIALS

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[Microsoft Teams Meeting Link](#)

### Abstract

Cavitation is defined as the formation and growth of the gaseous bubble in bulk liquid due to the tensile pressure followed by the violent collapse. The collapse of the bubble is particularly significant due to its potential to cause damage to relatively stronger materials by either creating pressure waves (symmetric collapse) or liquid jet (asymmetric collapse). The study of cavitation in soft materials (e.g., tissue, brain, gelatin gel, etc.) has, therefore, gained a fair share of attention in the scientific communities. Recent studies have indicated that cavitation could be one of the leading causes of the mild Traumatic Brain Injury (TBI) and greatly motivates us to study the cavitation mechanism in soft materials from a multiscale perspective. The goal of this work is to study, i) cavitation onset criteria, ii) damage intensity, and iii) axonal damage mechanism.

The microstructure of the gelatin gel is studied by observing the scanning electron microscope (SEM) images of the random fiber network (RFN). The geometric and material properties are evaluated by proposing a unit cell model of the network. A theoretical model is developed to incorporate the bubble growth in the network to quantify the threshold tensile pressure as the onset criteria of cavitation in soft materials.

The study of the onset criteria is followed by the study of cavitation damage intensity in soft materials. Shock-bubble interaction with symmetric collapse has been studied. A multiphase, compressible, and viscoelastic computational fluid dynamics (CFD) model has been developed to simulate the bubble dynamics. Several damage criteria (e.g., stress, strain, and energy based) have been proposed, and a parametric study has been done.

Finally, a complete material characterization of the neuronal cell (e.g., axon) has been performed. A representative volume element (RVE) of the axon is developed based on its cytoskeletal components. Nine independent (orthotropic) viscoelastic relaxation modulus are evaluated by nonlinear regression fit to the Prony series. This viscoelastic constitutive model of axon will be used to study the diffuse axonal injury (DAI).