Tissue damage produced by cavitation: The role of viscoelasticity

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Cavitation may cause damage at the cellular level in a variety of medical applications, e.g., therapeutic and diagnostic ultrasound. While cavitation damage to bodies in water has been studied for over a century, the dynamics of bubbles in soft tissue remain vastly unexplored. One difficulty lies in the viscoelasticity of tissue, which introduces additional physics and time scales. We developed a numerical model to investigate acoustic cavitation in soft tissue, which accounts for liquid compressibility, full thermal effects, and viscoelasticity (including nonlinear relaxation and elasticity). The bubble dynamics are represented by a Keller-Miksis formulation and a spectral collocation method is used to solve for the stresses in the surrounding medium. Our numerical studies of a gas bubble exposed to a relevant waveform indicate that under inertial conditions high pressures and velocities are generated at collapse, though they are lower than those observed in water due to the elasticity and viscosity of the medium. We further find that significant deviatoric stresses and increased heating in tissue are attributable to viscoelasticity, due to material properties and different bubble responses compared to water.