Special Program in Applied Mathematics and Applied Mechanics

Damage potential of bubbles collapsing in and near soft objects

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Cavitation commonly occurs in naval applications, such that considerable research activities have been dedicated to understanding cavitation dynamics in water and the impact on neighboring hard, metallic objects, e.g., vibrations, structural damage, etc. However, this knowledge does not immediately translate to bubble dynamics near soft materials, a phenomenon central to a variety of medical (therapeutic ultrasound, traumatic brain injury) and naval (erosion-resistant elastomeric coatings) applications. The complex rheology of soft matter and the strong coupling between the bubble and its surroundings pose significant challenges for predicting soft matter response to cavitation, including potential damage, at such high rates. This presentation summarizes our efforts toward developing numerical models and methods for simulating bubble dynamics in and near soft materials and applying these techniques to understand basic mechanics underlying these problems. Our numerical investigations of single-bubble problems have shed light on the role of viscoelasticity on the bubble dynamics characteristics, e.g., oscillation damping/frequency and bubble morphology, as well as quantified stresses and temperatures experienced in the surrounding medium. Our findings further indicate that, besides shock waves and liquid jet impacts known to erode hard materials, additional mechanisms such as viscous and elastic stresses, as well as local heating, are likely to contribute to damaging soft matter. Whether cavitation-induced damage is intended or not, this knowledge is essential to planning safe and efficient ultrasound procedures, as well as improving the design of cavitation-resistant materials.

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