Numerical investigation of viscoelastic solid deformation induced by bubble collapse

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Abstract

Bubble collapse is critical in various fields such as manufacturing, medical and environmental applications, including water electrolysis enhancement, drug delivery and water treatment. The strong pressure waves generated during bubble collapse can significantly affect nearby solid or biological structures. A comprehensive understanding and prediction of bubble collapse and the resulting solid deformation is essential for optimizing practical applications. Despite extensive studies, a general predictive model for bubble collapse and solid deformation has not yet developed due to the challenges in tracking microscale multi-interface interactions. In this work, a numerical approach is developed for ultrasound-driven bubble collapse and viscoelastic solid deformation. The level-set method is extended to track multiple bubble and solid surfaces in compressible multiphase flows, further enhanced to capture viscoelastic solid deformation using an Eulerian formulation of the left Cauchy-Green deformation tensor for neo-Hookean materials. Simulations of ultrasound-driven microbubble collapse in water demonstrate solid deformation throughout the entire bubble oscillation cycle. The effects of acoustic pulse amplitude, frequency and material properties on bubble motion and solid deformation are quantified. * This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT)(RS-2024-00350110).

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