Effects Of Coupling, Bubble Size, And Spatial Arrangement On Chaotic Dynamics Of Microbubble Cluster In Ultrasonic Fields

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ABSTRACT

Microbubble clustering may occur when bubbles become bound to targeted surfaces or are grouped by acoustic radiation forces in medical diagnostic applications. The ability to identify the formation of such clusters from the ultrasound echoes may be of practical use. Nonlinear numerical simulations were performed on clusters of microbubbles modeled by the modified Keller-Miksis equations. Encapsulated bubbles were considered to mimic practical applications but the aim of the study was to examine the effects of inter-bubble spacing and bubble size on the dynamical behavior of the cluster and to see if chaotic or bifurcation characteristics could be helpful in diagnostics. It was found that as microbubbles were clustered closer together, their oscillation amplitude for a given applied ultrasound power was reduced, and for inter-bubble spacing smaller than about ten bubble radii nonlinear subharmonics and ultraharmonics were eliminated. For clustered microbubbles, as for isolated microbubbles, an increase in the applied acoustic power caused bifurcations and transition to chaos. The bifurcations preceding chaotic behavior were identified by Floquet analysis and confirmed to be of the period-doubling type. It was found that as the number of microbubbles in a cluster increased, regularization occurred at lower ultrasound power and more windows of order appeared.

KEYWORDS: Fluid bubbles; Bifurcations; Ultrasonography

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