ACOUSTICS2008/2377
Stability and simulations of pulsating contrast agents

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The encapsulating membrane of ultrasound contrast agents, UCA's, is treated as a viscoelastic thin shell whose deviation from linear Hookean behavior is modeled as a strain softening or strain hardening effect via a parameter measuring the degree of membrane softness. As the amplitude of sound increases it controls the shift in resonance frequency until it hits the forcing frequency in which case an abrupt increase in the microbubble response takes place. Only strain softening shells exhibit this behavior. Deviations from sphericity are modeled via an additional parameter, namely the scalar bending modulus. This parameter controls static buckling of the shell, the onset of parametric instability and dynamic buckling. In this fashion phase diagrams can be constructed for a specific UCA that map regions of subharmonic growth of shape modes. Stability analysis and numerical simulations are employed in order to capture the onset, growth and break-up or saturation of shape modes. The above two parameters are added to the area dilatation modulus and viscosity of the membrane in order to construct a model that can be used to design new agents that behave optimally in different diagnostic or therapeutic modalities.