Parametric Stability and Numerical Simulations of Insonated Contrast Agents

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ABSTRACT

Contrast agents are encapsulated microbubbles, known to exhibit dynamic patterns such as thresholding [1], compression only [2] behavior, diffusion and deflation, shape deformation [3], buckling [4], jetting and break-up, not all of which can be adequately predicted based on a single model describing the mechanics of the coating. The effect of shell elasticity and viscosity as well as their nonlinear evolution with varying amplitude and frequency of the acoustic disturbance, is studied against the above patterns, first in the context of spherosymmetric pulsations. The superiority of strain softening models is discussed [5] and the relevance of strain hardening models is presented in the context of the "compression only" behavior of lipid coated microbubbles. The latter is associated with a folding instability [6] that occurs dynamically in the form of buckling and that is accelerated in the presence of prestress.

Next the dynamics of axisymmetic deformations is studied subject to different constitutive laws for the coating and the possibility for parametric mode excitation and resonance [7] is investigated. The boundary element methodology is adopted for simulating free pulsations of a contrast agent subject to acoustic disturbances and it is seen that strain softening shells exhibit saturated pulsations in the region where linear stability analysis predicts unstable growth of shape modes via harmonic and subharmonic resonance. The onset of static and dynamic buckling is also studied and possibilities for break-up and jet formation are discussed.

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