ACOUSTICS2008/1737
Local heating by a bubble excited by high intensity focused ultrasound

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A current topic of interest for high intensity focused ultrasound (HIFU) treatments involves the relative roles of bubbles and nonlinear acoustic propagation as heating mechanisms. At high amplitudes, nonlinear propagation leads to the generation of boiling bubbles within milliseconds; at lower amplitudes, cavitation bubbles can enhance heating through viscous dissipation, acoustic radiation, and heat conduction. In this context, understanding the physics attendant to HIFU bubbles requires consideration of gas-vapor bubble dynamics, including thermal effects in the nearby liquid. To this end, recent experimental observations with high-speed photography suggest that bubbles undergo a brief period of growth after application of HIFU has stopped. To explain this observation, a model is implemented that couples the thermodynamic state of a strongly driven bubble with thermal conditions in the surrounding liquid. From model simulations, liquid heating in the vicinity of a HIFU bubble is estimated. Calculations suggest that thermal conduction and viscous dissipation can lead to the evolution of a nontrivial thermal boundary layer. Development of a boundary layer that reaches superheated temperatures would explain the aforementioned experimental observation. As such, cavitation bubbles and boiling bubbles share important characteristics during HIFU.
[Work supported by NIH DK43881 and NSBRI SMS00402.]