Heat and mass transfer effects on forced radial oscillations in soft tissue

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Cavitation has a vast array of biomedical purposes such as histotripsy, used to mechanically fractionate soft tissue. Alternatively, cavitation can cause unwanted biological damage in diagnostic ultrasound, e.g., when using ultrasound contrast agents. These benefits and harmful effects make it desirable to develop models to better understand cavitation in viscoelastic media. We numerically model cavitation in a viscoelastic (Kelvin-Voigt) medium using the Keller-Miksis equation to describe the radial bubble motion. We specifically focus on the effects of heat and mass transfer, through numerical solution of the full energy and mass equations, reduced models, and theoretical analysis. We will discuss how thresholds on the driving pressure and frequency where thermal and mass transfer effects become significant can be determined, as well as ranges of amplitudes for which reduced models can be used accurately. We will also present theoretical investigations on how oscillation properties depend on these effects. Our findings will provide guidelines to determine regimes when heat and mass transfer are dominant. [This work was supported in part by NSF grant number CBET 1253157 and NIH grant number 1R01HL110990-01A1.]