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Mathematical models and multiharmonic algorithms for contrast-enhanced ultrasound

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Contrast-enhanced ultrasound is a valuable tool in biomedical applications, using gas-filled microbubbles to enhance both diagnostic and therapeutic imaging. Once injected, microbubbles oscillate nonlinearly in response to ultrasound waves, making sound propagation through bubbly liquids a highly nonlinear problem. This behavior is modeled by a nonlinear acoustic wave equation coupled with Rayleigh–Plesset-type models for bubble dynamics. In this talk, we derive such coupled models from constitutive laws and then based on the periodic-in-time nature of the excitation, we further develop multiharmonic algorithms for computing time-periodic solutions. These methods significantly reduce computational cost compared to time-stepping approaches while accurately capturing nonlinear effects. Numerical experiments demonstrate the efficiency of the proposed algorithms.

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