Nonsmooth Problems with Applications in Mechanics
Olomouc, Czech Republic, May 19-23, 2025

Subharmonic vibrations of microbubbles in the cloud driven by ultrasound

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Abstract: This work investigates the dynamics of microbubbles driven by ultrasound. Due to the nonlinearities inherent in the governing equations, advanced numerical methods are required for accurate analysis. Instead of using commercial software, dedicated algorithms were developed and applied to solve these model equations. Dynamical simulations were conducted for systems containing 10, 20, and 100 bubbles of either uniform or random sizes, randomly distributed in space. The temporal evolution of bubble sizes, emissivity, and inter-bubble interactions was analysed. The results demonstrate that even small variations in bubble polydispersity can significantly influence the components of the scattered pressure spectrum. Increasing the dispersion of bubble radii led to the emergence of half-subharmonics across the entire range of driving frequencies. In contrast, for non-interacting bubbles of uniform size, half-frequency subharmonics appeared only at a single excitation frequency corresponding to twice the resonance frequency of an individual bubble. A detailed stability analysis reveals that phenomena previously interpreted as chaotic behavior in bifurcation diagrams are, in fact, artifacts of the numerical methods employed.